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THE RETARDING EFFECT OF PROTRACTED UNDERNUTRITION ON THE APPEARANCE OF THE POSTNATAL OSSIFICATION CENTERS IN THE HAND AND WRIST[1]

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INTRODUCTION

THE oldest and most frequent observation of the effect of undernutrition on skeletal development is a failure to attain expected height. For years, experts have differed in their interpretation of the over-all effect of genetic and nutritional influences on skeletal maturation (Pryor, '36; Sontag and Lipford, '43; Todd, '37; Francis, '39). The advent of roentgenography has permitted important studies of the relation of undernutrition to certain specific features of skeletal development. A prominent aspect readily detectable in serial roentgenograms is

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the initial appearance of the postnatal primary and secondary centers of ossification. Todd ('37) and Francis ('39) were among the first to direct attention to the retarding influence of undernutrition on the conversion of the cartilaginous primordium into osseous tissue. Supportive evidence has since been forthcoming from the cross-sectional studies of Abbott, Townsend, French, and Ahmann ('50) in Florida and of Beresowski, and Lundie ('52) in South Africa. A similar impression has been gained in the course of longitudinal studies of approximately 1,000 children at the Nutrition Clinic of the Hillman Hospital, Birmingham, Alabama during the past 17 years. With the accumulation of data derived from a large series of sequential roentgenograms, it is now possible for the first time to make a qualitative and quantitative evaluation of the effect of prolonged undernutrition during infancy and childhood on the onset of ossification in the postnatal centers of the hand and wrist.

MATERIALS AND METHODS

Five hundred and forty-one white, native-born Alabama children of similar ethnic background were arbitrarily selected from the growth study group of the Nutrition Clinic. Serial sequential roentgenograms of the left hand and wrist covering the period during which some or all of the postnatal ossification centers are scheduled to appear were available for each of the 301 boys and 240 girls. Every child was studied carefully and individually including a detailed medical, dietary, family and socio-economic history. Each child selected had evidence consistent with a clinical diagnosis of undernutrition.

The roentgenograms were taken at intervals of three months until a child reached his fifth birthday, and every 6 months thereafter. The size of the series of roentgenograms varied with the age at which the child was accepted for study. Only children with a series in which a reasonably accurate age of appearance of a particular ossification center could be determined were included. When the center appeared between the taking of two roentgenograms, the time of appearance was extrapolated to the nearest month on the basis of the configuration of the center when first seen. The primary ossification centers in the carpus, the secondary ossification centers in the metacarpals, phalanges and distal radius and ulna, and the flexor and adductor sesamoids of the thumb were included in the assessment. The age for the appearance of each of these centers as depicted in the Greulich-Pyle Radiographic Atlas ('50) served as the standard of reference.

OBSERVATIONS

The distributions of the times of appearance of the primary and secondary postnatal ossification centers in the hands and wrists of the undernourished children appear in tables 1 and 2. The frequency of retardation was statistically significant for each center in the boys except those of the adductor sesamoid of the thumb and the distal radius (table 1). The differences between the number delayed and the combined number advanced and on schedule were significant at the 5% level for the capitate and hamate; for all other centers the significance was at the 1% level. In the girls (table 2), statistically significant frequencies of delay were recorded for each center except those of the proximal phalanges II through V and the distal phalanx of the thumb. All but one of the significantly retarded values were at the 1% level; that for distal phalanx III was at the 5% level.

In both the boys and the girls the mean times of appearance for each center were retarded, the delays ranging from 1.2 months (adductor sesamoid of the thumb) to 28.9 months (greater multangular) in the boys and from 1.8 months (proximal phalanx III) to 18.3 months (greater multangular) in the girls. In general, the delay was most accentuated in the carpals (capitate and hamate excluded) followed in decreasing magnitude by the distal ulna, metacarpals, terminal phalanges, middle phalanges, proximal phalanges, and distal radius. Save for the capitate, hamate, and adductor sesamoid of the thumb, the mean extent of retardation in the appearance of each center in the boys greatly exceeded the corresponding values for the girls. For the group, the centers which most closely approximated the Greulich-Pyle ossification schedules were the adductor sesamoid of the thumb in the boys and proximal phalanges II, III and IV in the girls. The comparatively high values for the standard deviations for each center, which frequently exceeded the mean in magnitude, were indicative of a high degree of variability in the time of appearance of the ossification centers in the children comprising this study group.

The number of ossification centers used in the determination of time of appearance in the 541 children ranged from one to 30. In no child was it possible to evaluate all 31 centers usually assessed in the hand skeleton. The mean number of centers per child available for assessment of onset of ossification was 8.6 for the boys and 8.9 for the girls.

The frequencies of the combinations of types of deviation from the Greulich-Pyle standard of the time of appearance of the measurable

TABLE 1

Distribution of the appearance times of the postnatal ossification centers in the hand and wrist of undernourished boys based on the standard time of appearance for each center †

Ossification Center	Number of Cases	Advanced (+) Number	Advanced (+) Per Cent	On Schedule (O) Number	On Schedule (O) Per Cent	Delayed (—) Number	Delayed (—) Per Cent	Mean (Months)	Standard Deviation (Months)
Capitate	33	4	12.12	5	15.15	24*	72.72	—2.7	3.86
Hamate	35	4	11.43	6	17.14	25*	71.42	—4.9	10.71
Triquetrum	87	17	19.54	0	0.00	70**	80.46	—19.0	19.99
Lunate	92	10	10.87	1	1.09	81**	88.04	—26.9	20.89
Navicular	113	5	4.42	3	2.65	105**	92.92	—20.5	15.36
Gtr. Multangular	116	6	5.17	1	0.86	109**	93.96	—28.9	18.02
Lssr. Multangular	115	9	7.83	1	0.87	105**	91.30	—20.2	15.37
Pisiform	122	9	7.37	16	13.11	97**	79.51	—16.6	14.83
Metacarpal I	86	7	8.14	1	1.16	78**	90.69	—15.9	12.52
" II	74	4	5.41	3	4.05	67**	90.54	—10.7	7.57
" III	84	5	5.95	0	0.00	79**	94.04	—12.1	8.86
" IV	82	5	6.09	0	0.00	77*	93.90	—15.1	9.44
" V	75	15	20.00	2	2.67	58**	77.33	—9.7	10.20
Prox. Phalanx I	89	8	8.99	0	0.00	81**	91.01	—15.3	10.74
" " II	76	11	14.47	3	3.95	62**	81.58	—6.6	6.92
" " III	74	9	10.81	7	9.46	58**	78.38	—5.6	6.22
" " IV	76	8	10.52	4	5.26	64**	84.21	—8.0	7.38
" " V	80	6	7.50	5	6.25	69**	86.25	—8.7	7.93
Mid. Phalanx II	81	11	13.58	5	6.17	65**	80.25	—8.7	9.73
" " III	83	8	9.64	5	6.02	70**	84.33	—10.4	9.93
" " IV	83	10	12.05	4	4.82	69**	83.13	—10.4	9.99
" " V	92	11	11.96	6	6.52	75**	81.52	—13.5	13.78
Dist. Phalanx I	80	8	10.00	5	6.25	67**	83.75	—11.7	9.37
" " II	89	14	15.73	5	5.62	70**	78.65	—10.3	11.24
" " III	85	5	5.88	1	1.18	79**	92.94	—15.0	9.87
" " IV	83	5	6.02	1	1.20	77**	92.77	—15.7	10.42
" " V	89	14	15.73	6	6.74	69**	77.52	—10.5	11.49
Adductor Sesamoid	75	26	34.67	14	18.66	35	46.66	—1.2	11.97
Flexor Sesamoid	53	12	22.64	1	1.89	40**	75.46	—7.4	10.74
Distal Radius	70	23	32.85	6	8.57	41	58.57	—5.6	9.03
Distal Ulna	124	14	11.29	0	0.00	110**	88.71	—19.4	16.88

† Greulich-Pyle Standard.
* Significant at 5% level.
** Significant at 1% level.

* Significant at 5% level.
** Significant at 1% level.

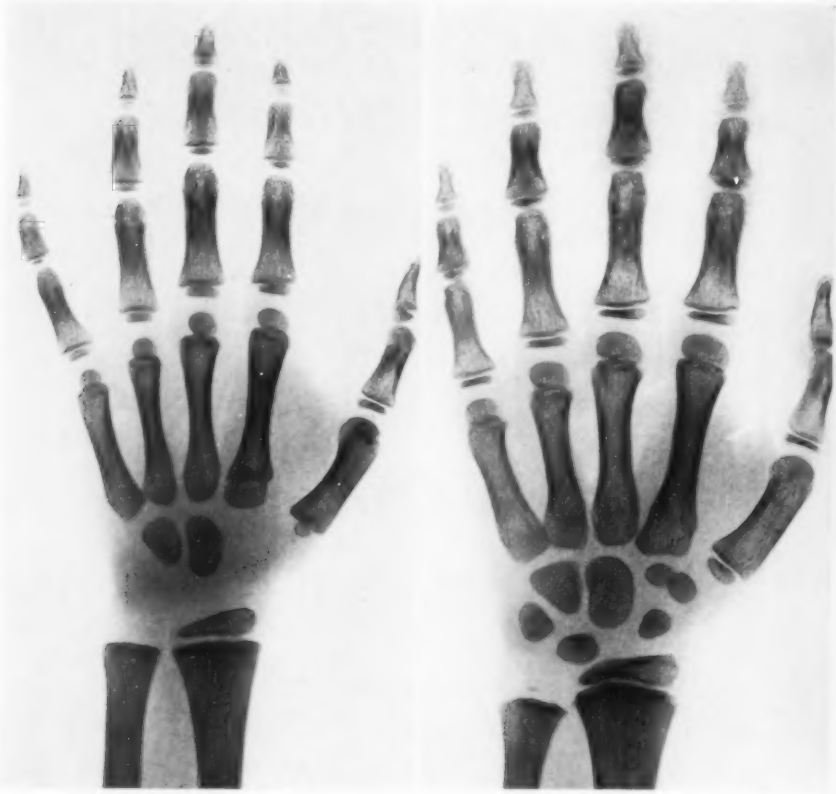
TABLE 2

Distribution of the appearance times of the postnatal ossification centers in the hand and wrist of undernourished girls based on the standard time of appearance for each center †

Ossification Center	Number of Cases	Advanced (+) Number	Advanced (+) Per Cent	On Schedule (O) Number	On Schedule (O) Per Cent	Delayed (—) Number	Delayed (—) Per Cent	Mean (Months)	Standard Deviation (Months)
Capitate	24	1	4.17	4	16.66	19**	79.16	—4.0	3.95
Hamate	24	1	4.17	4	16.66	19**	79.16	—5.0	6.24
Triquetrum	68	9	13.73	0	0.00	59**	86.27	—16.6	16.09
Lunate	84	11	13.09	2	2.38	71**	84.52	—15.4	17.00
Navicular	94	9	9.55	5	5.32	80**	85.11	—18.1	15.74
Gtr. Multangular	97	8	8.25	2	2.06	87**	89.69	—18.3	17.06
Lssr. Multangular	99	7	7.07	9	9.09	83**	83.83	—14.0	12.32
Pisiform	117	15	12.82	10	8.55	92**	78.62	—9.9	11.57
Metacarpal I	68	13	19.11	4	5.88	51**	75.00	—7.7	11.39
" II	57	4	7.02	6	10.53	47**	82.45	—5.1	5.08
" III	60	6	10.00	2	3.33	52**	86.66	—5.5	5.54
" IV	66	9	13.63	4	6.06	53**	80.30	—5.3	5.39
" V	63	7	11.11	5	7.93	51**	80.95	—7.4	8.81
Prox. Phalanx I	66	13	19.70	5	7.58	48**	72.72	—6.9	10.89
" " II	52	10	19.23	11	21.15	31	59.61	—2.3	4.55
" " III	54	12	22.22	13	24.07	29	53.70	—1.8	4.43
" " IV	55	10	18.18	13	23.64	32	58.18	—2.8	4.92
" " V	59	14	23.73	10	16.95	35	59.32	—3.2	7.11
Mid. Phalanx II	64	12	18.75	6	9.37	46**	71.88	—6.2	8.55
" " III	64	12	18.75	7	10.93	45**	70.31	—4.9	6.19
" " IV	65	13	20.00	7	10.77	45**	69.22	—4.9	6.39
" " V	74	11	14.86	3	4.05	60**	81.08	—6.4	10.52
Dist. Phalanx I	56	14	25.00	9	16.07	33	58.92	—3.5	6.68
" " II	73	12	16.43	6	8.22	55**	75.34	—6.8	7.79
" " III	61	18	29.51	2	3.28	41*	67.21	—4.6	8.44
" " IV	62	16	25.81	1	1.61	45**	72.58	—5.0	8.56
" " V	70	8	11.42	2	2.86	60**	85.71	—9.3	8.29
Adductor Sesamoid	83	17	20.48	11	13.25	55**	66.26	—6.9	10.95
Flexor Sesamoid	70	4	5.71	16	22.86	50**	71.43	—11.3	13.03
Distal Radius	53	9	16.98	6	11.32	38**	71.70	—3.4	5.14
Distal Ulna	115	7	6.09	6	5.22	102**	88.69	—15.5	12.14

† Greulich-Pyle Standard.
* Significant at 5% level.
** Significant at 1% level.

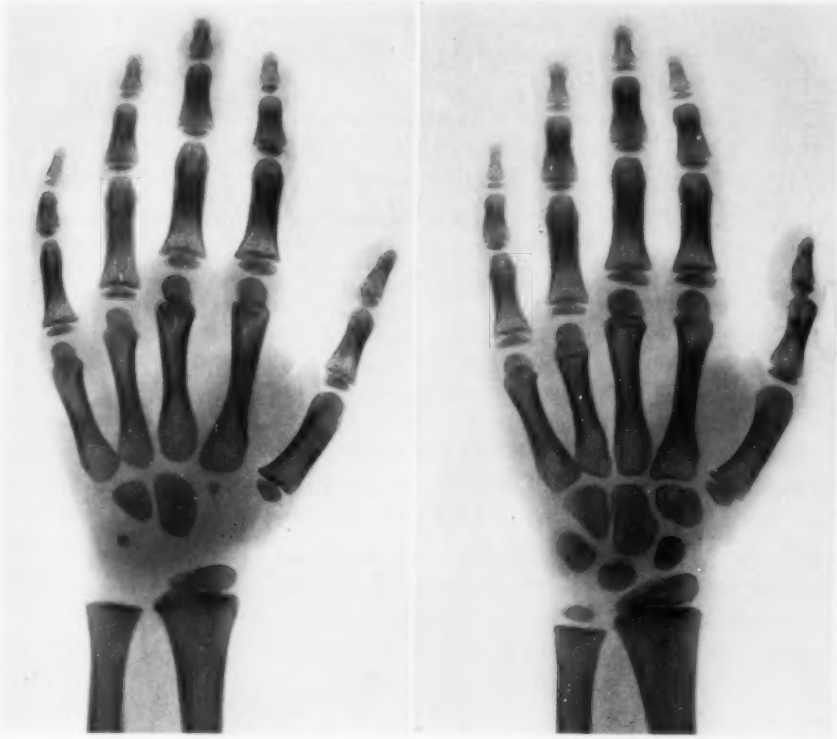
postnatal ossification centers in the 541 undernourished children are contained in table 3. These combinations refer to the total number of centers in each child in which the onset of ossification could be identified



C. A.: 7 yr. 3 mo C. A.: 7 yr. 4 mo.

FIG. 1. EFFECT OF KNOWN UNDERNUTRITION (LEFT) AND KNOWN ADEQUATE NUTRITION (RIGHT) AS SHOWN BY ROENTGENOGRAMS OF HAND SKELETON OF TWO BOYS FROM THE HILLMAN HOSPITAL NUTRITION CLINIC SERIES. ACCORDING TO THE GREULICH-PYLE STANDARD, BOYS WITH A SKELETAL AGE OF 7 YEARS SHOULD HAVE 7 CARPAL CENTERS WHEREAS ONLY TWO HAVE APPEARED IN THE HAND OF THE UNDERNOURISHED BOY. WELL-NOURISHED BOY IS SOMEWHAT AHEAD OF 7 YEAR OLD STANDARD OF GREULICH AND PYLE. OBSERVE PRESENCE IN HAND OF UNDERNOURISHED BOY OF PSEUDOEPIPHYSIS ON DISTAL END OF METACARPAL I AND ON BASE OF METACARPAL II. REMNANTS OF 7 TRANSVERSE LINES OF ARRESTED GROWTH NEAR DISTAL END OF SHAFT OF RADIUS ARE VISIBLE IN ROENTGENOGRAM OF THIS BOY.

in the roentgenograms. Collectively, a delayed appearance of some or all of the identifiable centers was found in 91.3% of the 541 children. In only 29 (5.4%) of the children was the ossification of all detectable



C. A.: 6 yr. 9 mo. C. A.: 6 yr. 11 mo.

FIG. 2. ROENTGENOGRAMS SHOWING EFFECT OF KNOWN UNDERNUTRITION (LEFT) AND KNOWN ADEQUATE NUTRITION (RIGHT) ON HAND SKELETON OF TWO GIRLS FROM THE HILLMAN HOSPITAL NUTRITION CLINIC SERIES. ACCORDING TO THE GREULICH-PYLE STANDARD, GIRLS WITH A SKELETAL AGE OF 6 YEARS 10 MONTHS SHOULD HAVE 7 CARPAL CENTERS; HOWEVER, ONLY 4 ARE PRESENT IN HAND OF UNDERNOURISHED GIRL. NOTE IMMATURITY OF THIS HAND AS SHOWN BY EXTENT AND CONTOURS OF BONY CENTERS WHEN COMPARED WITH THAT OF WELL-NOURISHED GIRL WHO IS ADVANCED SOMEWHAT BEYOND GREULICH-PYLE STANDARD.

centers ahead of schedule and in but three (0.5%) did all appear on schedule.

Quantitatively, the actual amount of deviation in the time of appearance of the postnatal primary and secondary ossification centers in the

TABLE 3

The combinations of advanced, on schedule, and retarded appearance of the postnatal ossification centers in the hand and wrist of 541 undernourished children

	COMBINATION													
	—		—: O		—: +		—: O: +		O		O: +		+	
GROUP	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Boys	162	53.8	35	11.6	40	13.3	40	13.3	2	0.6	3	0.9	19	6.3
Girls	105	43.3	45	18.7	33	13.7	44	18.3	1	0.4	2	0.8	10	4.2
Total	267	49.3	80	14.8	73	13.5	84	15.5	3	0.5	5	0.9	29	5.4

— = Retarded
O = On Schedule
\+ = Advanced

hand and wrist of the 541 undernourished children encompassed a range of 116 months. In the boys, the range of deviation extended from 42 months advanced for an adductor sesamoid of the thumb to 92 months delayed for a navicular. The range in the girls extended from 24 months advanced for an adductor sesamoid of the thumb and a lunate respectively, to 65 months delayed for a metacarpal I. In both sexes the carpal centers were the most severely retarded in onset of ossification. In the boys the greatest amount of delay was found most frequently in the greater multangular, with 29.3% of those examined having a handicap exceeding 36 months. In the girls the greatest frequency of retardation in time of appearance in excess of 36 months, which characterized 19.05% of the cases, occurred in the lunate. Among the secondary centers of ossification, that of the distal ulna had the highest frequency in excess of 36 months, the percentages being 14.5 and 4.3 for the boys and girls respectively. Conversely, the least amount of deviation from the standard schedule of appearance for the primary centers of ossification was shown by the capitate in both sexes. None exceeded a delay of 18 months in the boys and 15 months in the girls. The least delay found in the secondary centers was in the proximal phalanx of the third digit in boys (none exceeding 21 months) and in metacarpal IV and the proximal phalanx of the second and fifth digit in the girls (none exceeding 15 months). In both sexes the temporal range of appearance was lowest in the proximal phalanges. In the boys the great bulk of the values fell between plus 9 and minus 24 months; in the girls between

plus 9 and minus 18 months. The metacarpals in the girls showed a similar clustering. Of the two long bones of the forearm, the center of the distal ulna in both sexes showed a considerably greater range in time of appearance than did that of the distal radius.

Specific examples of extreme delay in time of appearance of the carpal centers and skeletal maturation, generally, in the 301 boys and 240 girls are presented in figures 1 and 2. The roentgenograms of the undernourished pair are contrasted with those of well-nourished children of the same sex, chronological age, and ethnic origin. The skeletal maturation of the well-nourished children is slightly ahead of the standards contained in the Greulich-Pyle atlas.

DISCUSSION

Analysis of these data supports our previous observations that protracted undernutrition during infancy, childhood, and adolescence affects the maturation of the skeleton. Some of these effects include:

1) a signal failure to attain expected stature (Dreizen *et al.*, '53)
2) a high degree of asymmetry in the maturation of the hand skeleton (Pyle *et al.*, '48)
3) a lagging rate of skeletal development as measured by the Todd inspectional technique (Spies *et al.*, '53; Dreizen *et al.*, '54)
4) a considerable frequency and variety of anomalies in the bones of the hand (Snodgrasse *et al.*, '55a; Snodgrasse *et al.*, '55b)
5) a noteworthy persistance of radio-opaque transverse lines in the distal end of the shaft of the radius (Dreizen *et al.*, '56)
6) a delayed fusion of the epiphyses in the hand, and distal radius and ulna (Dreizen *et al.*, '57).

In the hand and wrist the time of onset of ossification is definitely more variable in the carpals than in the epiphyses (Pyle and Sontag, '43). The advent of ossification is more apt to be delayed by metabolic disturbances in the primary centers of the hand than in the epiphyseal centers (Francis, Werle, and Behm, '39). Francis ('39; '40) reported that inception of ossification in the postnatal centers is materially influenced by the available minerals and vitamins. Recently, the greater susceptibility of the maturation of the carpals than of the other centers in the hand and wrist to interference by intercurrent illness has been re-emphasized (Hewitt, Westropp, and Acheson, '55). The impression

that the carpal centers are more variable in time of appearance and more vulnerable to the retarding influence of protacted undernutrition is supported by the observations made on the present series of 541 chlidren. The finding that the capitate and hamate were the least delayed of the carpal centers in time of appearance accords with published reports (Todd, '37; Francis, Werle, and Behm, '39). In the present study, the greater multangular was the most retarded carpal bone in each sex.

Exclusive of the capitate and hamate and the metacarpo-phalangeal sesamoids of the thumb, the primary and secondary centers in the hand were less tardy in time of appearance in girls than in boys. This probably reflects the physiologically more rapid rate of maturation so characteristic of the female sex with the result that adverse environmental circumstances of the same degree of intensity affect males to a greater extent than females. This interpretation is supported by the studies of Greulich ('51; Greulich, Crismon, and Turner, '53) of the growth of Guamanian and Japanese children exposed to unfavorable environmental conditions.

SUMMARY AND CONCLUSIONS

The present study of 301 boys and 240 girls supports and extends our previous inference that protracted undernutrition during the growing period notably affects the postnatal development of the skeleton. Comparison of the roentgenographically detectable advent of ossification in 31 centers of the hand and wrist in the undernourished children with the age standards in the Greulich-Pyle atlas showed that:

1. The mean time of appearance for each of the 31 ossification centers was delayed in every instance in each sex. The mean amount of delay in the boys exceeded that of the girls for all but three centers.

2. The frequency of retardation in onset of ossification surpassed the combined frequency of centers appearing either early or on schedule to a statistically significant degree for 29 and 26 of the 31 centers in the boys and girls respectively.

3. Some or all of the assessable centers were delayed in 504 (91.3%) of the 541 children.

4. Delay in advent of ossification was much more pronounced in the carpals than in the metacarpal and phalangeal epiphyses. In both sexes the delay in the epiphysis of the distal ulna greatly exceeded that of the distal epiphysis of the radius.

5. Quantitatively, in boys the average delay ranged from 1.2 months for the adductor sesamoid of the thumb to 28.9 months for the greater multangular; and in girls, from 1.8 months for the proximal phalanx of the third digit to 18.3 months for the greater multangular.

This clear demonstration of the susceptibility of skeletal maturation to chronic undernutrition once again points to the imperative need for proper and persistent nutritional therapy in the treatment of growth failure resulting from nutritional inadequacy.

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FAT, BODY SIZE AND GROWTH IN THE NEWBORN

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INTRODUCTION

THE size of the infant at birth and the thickness of the subcutaneous fat are obviously correlated variables. Large neonates and post-term infants are not only heavy, but they are well filled out. Small infants, and especially those prematurely born tend to be deficient in superficial fat. Yet within these limits there are many exceptions. The newborn include some long but skinny infants, and others (especially among diabetic progeny) who are excessively fat for their size. The extent of the fat-size relationship is thus a subject for inquiry, and one not touched upon in the literature on fatness (*cf.* Bernhardt, '55).

A second area for investigation is the sex difference in body fat. Girl babies tend to weigh less, but are developmentally more advanced at birth. Boy babies, on the other hand, are both longer and heavier on the average but less advanced developmentally, and notably less hardy. One possibility is that the female neonate has relatively more subcutaneous fat despite her smaller size, as is true in adulthood. Again, it is possible that the male neonate has more subcutaneous fat, a consequence of his greater size at birth. A third possibility is that, sharing a common uterine environment, and equally affected by maternal estrogens that penetrate the placental barrier, neonates of both sexes will tend toward equal superficial fat.

A third problem area concerns regional differences in size and their relationship to stored fat. If the fatter neonate is bigger, as seems to be the case, is he bigger overall, or is the fat-size relationship confined to particular body areas? There is a clinical supposition that the fat new born is disproportionately long in the trunk and relatively short

of leg, but this may be an illusion due to the fact that the legs of fat infants look shorter.

In the course of our investigations on growth and development, we have had the opportunity to explore fat-size relationships in a sizeable series of healthy developmentally-mature white infants from a fairly homogeneous population sample. Our data have included not only information on the infants themselves, but a considerable body of data on the mothers, including a number of variables that may relate to individual differences in body fat. It is, therefore, possible to provide new data, not only on relative fatness in the newborn, but also on the determinants and consequences of differences in stored fat.

METHODS AND MATERIALS

The present investigation is primarily based on roentgenogrammetric and anthropometric measurements of 146 developmentally-mature Ohio-born neonates, and 95 mothers from Southwestern Ohio, all regular participants in the Fels Longitudinal Studies. Non-whites, twins and triplets and prematurely-born infants were excluded from the tabulations as were those with known developmental defects. The data thus pertain to a group of neonates with a median estimated length of gestation of 265 days, and a median birth weight of 3,390 gm.

Using the classification of Warner *et al.* ('49) the families involved were principally lower-middle class, with an effective range of upper-lower to upper-middle. Occupationally, nearly 25% of the fathers were engaged in farming and farm-related tasks, and 30% were tradesmen, salesmen and industrial workers. Abaut 40% of the fathers and 60% of the mothers had gone beyond a high school education (*cf.* Crandall and Preston, '56; Sontag, Nelson and Baker, '58). The sample, then consists of semi-urban lower-middle and comparatively well-educated families generally of "old American" ancestry.

Anthropometric data on the infants included birth weight (as measured in the hospital nursery) and the crown-heel diameter, as measured by the Fel pediatrician upon examining the child in the hospital. The remaining long-bone and fat measurements were derived from "birth" x-rays taken at the hospital and contained in the Fels longitudinal files. Anthropometric data on the mothers included stature, weight at the third month of pregnancy, and the last measured weight prior to delivery. From the third month and final pregnancy weight the rate-of-gain was calculated, on an individual basis, by dividing

the measured weight gain by the actual number of days intervening. Data on maternal body composition were based on roentgenogrammetric estimates, and by subtraction from the weight in the third month of pregnancy.

To test the representativeness of the sample, anthropometric data on the Fels neonates and the pregnant mothers were compared to data on mothers and infants from a private obstetric practice in Dayton, Ohio, but limiting the obstetric sample to the same range of gestation lengths (median, 265 days; standard deviation, 8 days) and to developmentally-mature singlings. Median values for birth size closely matched in the two samples. Maternal weight at 3 months for the Fels mothers was 59.9 kg, about 3.5 kg higher than in the obstetric group: the 9-month weights were almost identical. Accordingly it was felt that the Fels sample was reasonably representative of the larger local population.

The roentgenogrammetric measurements on the infants were made directly on the antero-posterior "birth" x-rays,[1] which were usually taken on the second day after birth, with a standard deviation of one day. The bony measurements included femoral length (F) and humeral length (H), as shown on figure 1, and spine length (S). Both femoral and humeral length were measured as the maximum extent of calcification along the shaft, but excluding epiphyses where present. Spine length (T_1-L_5) was also taken as a maximum, but without excluding individuals with sacralized lumbar vertebrae or lumbarized sacral vertebrae, because of the still immature state of ossification.

Subcutaneous fat, or more correctly the fat-plus-skin shadow was measured uniformly at the level of the lowest large rib (usually R_{11}), and usually on the right side.[2] Selection of this site was dictated by several factors, one being the fact that the lower limbs were only occasionally included and properly positioned on the birth "torso" x-ray, and the second being the desirability of using a site that could be measured either by pinch-caliper or x-ray on infants and adults alike. Previous studies from this institution have shown the utility of the

[1] The gonadal exposure incurred in a "birth-torso" x-ray, using high-speed film and 40–50 PKV at 10 milliampere seconds but without gonadal shielding is estimated at 15–30 milliroentgens (.015–.030 *r*) depending on size and sex.

[2] In an initial pilot study using the present material, no systematic difference was found between fat-shadow measurements on the left and right sides respectively. However, in individual cases, where there was evidence of axial rotation, the averaged value $\frac{L+R}{2}$ was employed.

lower-thoracic (LT) fat site (Garn, '56a, '57b; Garn and Gorman, '56), and the present investigation thus adds to the body of information on LT fat.

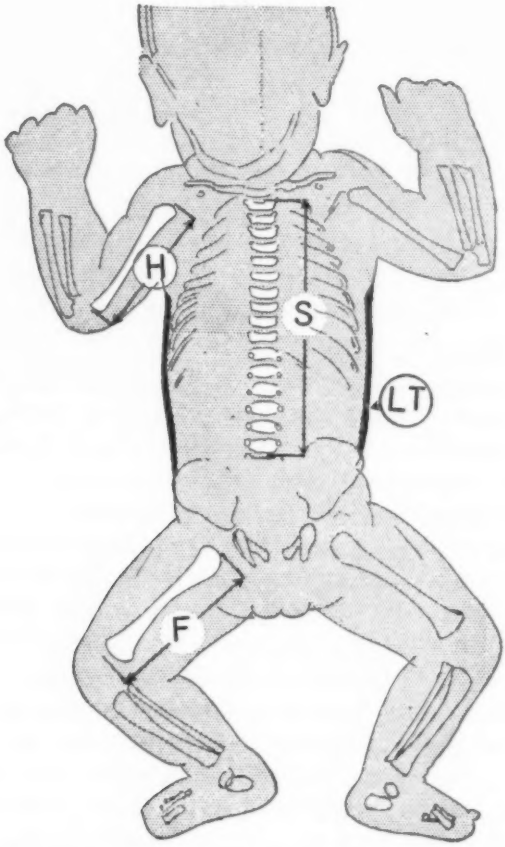

FIG. 1. TRACING OF AN ANTERO-POSTERIOR "BIRTH" X-RAY SHOWING THE FOUR DIMENSIONS MEASURED: H, HUMERAL LENGTH; F, FEMORAL LENGTH; S, SPINE LENGTH (T_1-L_5); LT, FAT-PLUS-SKIN SHADOW AT THE LEVEL OF THE LOWEST RIB. FOR CLARITY THE REST OF THE SUBCUTANEOUS FAT SHADOW IS NOT SHOWN.

Estimates of the maternal fat-free weight, which were used to further fractionate gross weight into physiologically meaningful compartments, were based on iliac fat measured on x-rays taken subsequent to delivery, using the technique of subtracting the estimated weight of fat from gross weight: the value of the constant a was 0.72, as previously

described (Garn, '57a). The assumption of a relatively constant fat-free weight was made; this is obviously a limiting assumption but not necessarily an incorrect one (*cf.* Garn, '57a, p. 346).

Since subcutaneous fat and weight were non-normal in distribution, and showed the types of skewness encountered in previous studies, all raw-score distributions were normalized using McCall's technique. The effectiveness of the McCall technique has been investigated by Lacey ('56), and is pictured in figure 20 in Garn and Shamir ('58). Accordingly, the product-moment correlations given in tables 2 through 4 are based on normalized T-scores, and tend to be slightly smaller than comparable correlations using the raw values. However, the fat-weight plot pictured in figure 5 employs raw scores, since it is the purpose of this scattergram to show the fat-weight relationship in normal and in diabetic progeny.

Since the Fels Longitudinal Studies are of the continuing type with constant recruitment, the possibility of secular trends and the further possibility of a changing population sample were considered. However, when the data were sorted according to year of birth, no consistent trend emerged, and there was no evidence that the selection of Fels parents had altered appreciably over the years.

FINDINGS

1. *Fat thickness and sex differences.*

Before attempting data analysis, cumulative frequency distributions for lower thoracic (LT) fat were drawn for boys and girls respectively, and then examined for sex differences and for skewness. As shown in figure 2, considerable skewness (of the type previously encountered for fat distributions) was evident in the fat distributions for both sexes.[3] Accordingly, percentiles were computed, rather than the familiar means and standard deviations, and the median was employed as a measure of central tendency. With one exception indicated in the text, all correlations were then based on normalized T-scores, rather than on the obviously skewed raw scores.

As shown in table 1, where the 5th and 95th percentile range is given, there is a wide span of values for LT fat in the newborn, infants at the

[3] Pearson's coefficient of skewness (S_K) was 0.58, using the combined-sex cumulative frequency distribution, and calculating the interquartile range by interpolation (*cf.* Arkin and Colton, '56, pp. 40-41).

95th percentile having approximately 2.3 times the thickness of fat of those in the 5th percentile. With regard to sex, however, there appears to be no important fat difference, the medians being almost identical—2.9 and 3.0 mm for boys and girls respectively. The distributions were also quite similar, to the extent that a combined-sex tabulation seemed justified, thus making maximum use of the data on all 146 neonates (*cf.* table 1).

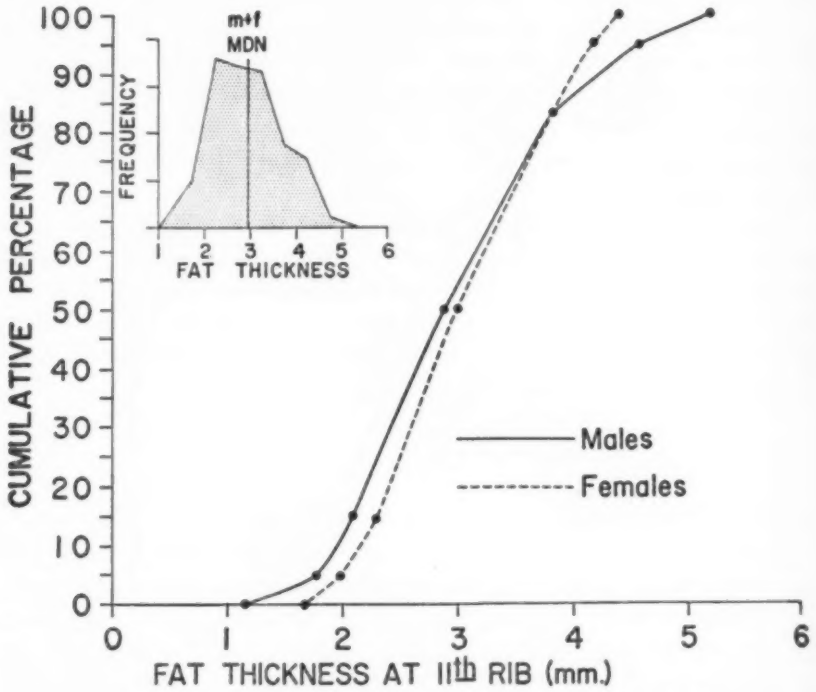

FIG. 2. CUMULATIVE FREQUENCY CURVES FOR LT FAT IN NEWBORN BOYS AND GIRLS. THE TWO CURVES, BOTH OF WHICH ARE SKEWED TO THE RIGHT, DISPLAY LITTLE SEXUAL DIMORPHISM. THE COMBINED-SEX FREQUENCY DISTRIBUTION CURVE IS SHOWN ABOVE.

Despite the virtual identity of fat-thickness values for male and female newborn, it seemed likely that the fat-weight ratios would differ, since the boys tended to weigh more than the girls (boys' Mdn. 3430 gm, girls' Mdn. 3350). Accordingly, the fat-weight ratio, namely fat in mm divided by weight in kg, was computed on an individual basis for the 79 boys and 67 girls respectively. The mean values for the ratio were

TABLE 1

Lower thoracic (Lt) fat percentiles for newborn boys and girls

SEX	No.	FAT PERCENTILES (MM)				
		5th	15th	50th	85th	95th
Males	79	1.8	2.1	2.9	3.9	4.6
Females	67	2.0	2.3	3.0	3.9	4.2
Combined	146	1.9	2.2	2.9	3.9	4.4

then 0.83 for boys and 0.93 for girls, and the difference (0.10) was significant at better than the 1 per cent level, using Student's *t*-test. While it was true that the sex difference in the ratio was due entirely to the difference in birth weight, it was still evident that the female neonate has a thicker deposit of subcutaneous fat relative to her weight, as is true in later life as well (*cf.* Garn, '57a).

2. *Determinants of birth fat.*

Attention was next directed to a number of variables known to be positively correlated with birth weight, and conceivably related to differences in the degrees of fatness at birth. These included (a) gestation length, since even the small residual variability might loom large in terms of fat deposition, (b) maternal size and weight (big mothers tend to have big babies), and (c) the maternal weight gain. Sibling similarities were also investigated, since tnese could shed some light on the extent to which subcutaneous fat deposition during late pregnancy is under fetal control. Certain variables, positively and significantly correlated with birth size were not considered however, because their relationship to fatness at birth seemed tenuous. Thus, while paternal length was significantly related to birth length ($r = 0.30$ for 58 boys and girls) there was no logical reason to connect the father's stature with the infant's fatness.

As shown in table 2, maternal weight at 3 months, the maternal 6-month weight gain, the mother's fat-free mass and gestation length were all positively and significantly related to birth weight. The sibling correlation was similarly significant and of the order of magnitude commonly encountered. Big women, with a large fat-free mass who carried their babies longer, and who gained more weight during pregnancy did have bigger babies. But maternal size, the length of gestation, and most other variables that were significantly correlated with birth weight were consistently unrelated to fat thickness at birth.

TABLE 2

Determinants of birth-fat weight and birth fat [1]

CORRELATION	SEX	N	r	Se_r
1. Maternal weight (3 mo)				
and birth weight	MF	95	0.23 [3]	0.10
... birth fat	MF	90	0.11	0.10
2. Maternal weight gain				
and birth weight	MF	95	0.21 [3]	0.10
... birth fat	MF	90	—0.04	0.11
3. Maternal fat-free weight [2]				
and birth weight	MF	71	0.34 [3]	0.11
... birth fat	MF	49	0.32 [3]	0.13
4. Gestation length				
and birth weight	MF	133	0.37 [3]	0.08
... birth fat	MF	61	0.12	0.13
5. Sibling correlation				
... birth weight	MF	61	0.28 [3]	0.12
... birth fat	MF	61	0.03	0.11

[1] Based on sex-specific T-scores, pooled for maximum sample size.

[2] Since the correlation between the maternal fat-free weight and the maternal weight of fat is —0.13, the correlations given here are substantially the same as the partial correlations.

[3] Significantly different from zero at $p = 0.05$ or better.

These findings, while disappointing insofar as birth fat was concerned, tended to confirm previous evidence that it is fat-free weight or lean body mass that is primarily involved in the body-size birth-size relationships. In fact, the highest correlation (0.49 for 50 cases) was obtained between the estimated maternal fat-free weight and the estimated fat-free weight of the newborn. The parental contribution, whether operating through the fetus or through the placental barrier seems to involve the fat-free size, while variations in the extent of fatness at birth still remain to be elucidated (*vide infra*).

3. *Fat and size in the newborn.*

Next, the relationship between fat at birth and various bodily dimensions was investigated, using anthropometric data collected at or shortly after birth, and measurements of long-bone and axial length obtained from the "birth" x-rays, as described in the previous section.

As shown in table 3, fat thickness and birth weight were moderately co-variant with a combined-sex correlation of 0.63 for the total series of 146. Expectably, the crown-heel length was also significantly and positively correlated with fat thickness at birth. Clearly, fat babies weighed more and were longer though part of the fat-weight correlation was due to the mutual relationship between size and weight.

TABLE 3

Relationship between fat thickness and body size at birth

CORRELATION BETWEEN FAT-PLUS-SKIN SHADOW AT 11TH RIB AND:	MALES			FEMALES			COMBINED [1]		
	N	r	Se_r	N	r	Se_r	N	r	Se_r
Birth weight	79	0.64	0.07	67	0.63	0.07	146	0.63	0.05
Crown-heel length	75	0.23	0.11	67	0.27	0.11	142	0.25	0.08
Spine length (T_1-L_5)	79	0.38	0.10	67	0.32	0.11	146	0.35	0.07
Humeral length	76	0.38	0.10	65	0.11*	0.12	141	0.25	0.07
Femoral length	69	0.30	0.11	59	0.13*	0.13	128	0.22	0.08

[1] Using sex-specific T-scores.

* Not significantly different from zero at $p = 0.05$ or better. Remaining 13 correlations significant.

The roentgenogrammetric measurements of skeletal size similarly indicated a positive relationship with fat thickness at birth. Spine length (T_1-L_5), humeral length and femoral length all yielded statistically significant correlations of the order of 0.2 to 0.3. Evidently, increased size associated with greater fat at birth involves both the axial skeleton and the long bones (despite the disproportionate prenatal growth of the trunk), and arm and leg length to a comparable degree, despite the relatively large size of the upper extremities at the time of birth.

These size-fat correlations further provided some indication that the technically difficult crown-heel measurement, is still as reliable an indication of length, as the more exact measurements of bone length, or rather the extent of ossification detectable on normally-exposed radiographs.

4. *Birth fat and subsequent growth.*

In turn, fat-thickness at birth was investigated in relation to subsequent size and fat, and to the rate of growth during the first three

months of postnatal life. The variables thus considered included (a) leg fat at one month, as measured on antero-posterior x-rays of the left leg (for details see Garn, '56a), (b) crown-heel length and gross weight at 3 months and (c) the weight gain from birth to 3 months. Interpolation of values was not needed since the tolerance limits for the regular 3-months visit were plus or minus 1 day (*cf.* Garn and Shamir, '58, chapter 4).

As shown in table 4, the correlation between lower thoracic fat at birth and leg fat at 1 month was moderately high, 0.53 for 102 infants, thus suggesting an initially high correlation between the two areas. Expectably, both crown-heel length at three months and weight were positively correlated with birth fat, since the infants fatter at birth, started life both heavier and longer. Evidently, the developmental advantage associated with greater fatness at birth persisted despite the vicissitudes of the extrauterine environment.

TABLE 4

Fat thickness at birth and subsequent size [1]

CORRELATION BETWEEN FAT THICKNESS AT BIRTH AND:	No.	SEX	r	Se_r
1. Leg fat at 1 mo. (Garn *et al.*, '56a)	102	M&F	0.53 [2]	0.07
2. Weight at 3 months	94	M&F	0.29 [2]	0.10
3. Length at 3 months	119	M&F	0.21 [2]	0.09
4. Weight gain (birth to 3 mo.)	119	M&F	—0.27 [2]	0.09

[1] Based on sex-specific normalized T-scores.
[2] Significant at $p = 0.05$ or better.

Birth fat, however, was *negatively correlated* with weight gain during the first three months. This is shown by quartile sorts for fat as well as by the correlation coefficient. The infants in the lowest quartile for birth fat (Q_1) gained the most (2.68 kg), those in the second quartile were next (2.45 kg), infants in the third fat quartile gained 2.48 kg, while the fattest (Q_4) infants gained but 2.3 kg.

In short, babies who are fat at birth remain relatively fat during the first few postnatal months, they remain long, and (to a lesser degree) they remain heavy. They gain less weight after being exposed to the extrauterine environment, however, than do lean infants. A similar

phenomenon has been noted at the 9-month level (*cf.* Garn, '56a), and in both cases the explanation appears to be the same: fatter infants being relatively advanced developmentally have shifted to the next later and slower rate of growth, while the lean infants are still engaged in the previous and more rapid rate of gain.[4]

5. *Fat and weight in diabetic progeny.*

Finally, fat thickness and weight were investigated in a series of nine diabetic progeny, all of them the offspring of known diabetic mothers, and most of them delivered by Caesarian section well before term. Initial weights ranged from 2235 gm (below the accepted limit for "prematures") to a sizable 5085 gm. The median birth weight was 3387 gm thus approximating the mean for the normal series. Antero-posterior torso x-rays, on which the fat measurements were made, were taken generally on the second day after birth, thus corresponding to the radiographs used in the normative series.[5]

TABLE 5

Birth-weight and fat-thickness in nine diabetic progeny

HOSPITAL NO.	SEX	GESTATION MENSTRUAL (days)	BIRTH WEIGHT (gm)	LT FAT THICKNESS (mm)	FAT T-SCORE [2]
107324	m	238	2,235	3.2	52
115434 [1]	m	224	2,736	4.9	75
117515	m	245	3,005	3.4	55
114332	f	252	3,232	3.3	53
114189	f	259	3,388	4.1	64
108659	m	245	3,459	5.1	80+
121295	m	259	3,487	3.8	60
114994	m	266	3,770	4.3	68
116877 [1]	m	term	5,085	7.1	85++
Median			3,387	4.4	70

[1] Vaginal delivery, all other Caesarian sections.

[2] From Fels combined-sex normalized T-scores.

[4] Other studies have shown that infants who are small at birth grow more rapidly thereafter.

[5] These nine diabetic progeny, whose x-rays and protocols were furnished by Dr. Thomas Shaffer, University Hospital, Columbus, Ohio, included 7 born by Caesarian section, and 2 vaginal deliveries. Gestation lengths given in table 5 refer to menstrual days.

Despite the shortened length of gestation, the diabetic progeny were not limited in subcutaneous fat thickness. In fact, with fat thicknesses of 3.2 mm to 7.1 mm, none of the diabetic progeny fell *below* the median value for the normative series (see table 5). The "leanest" of the diabetic progeny had—at 32 developmental weeks of gestation and a birth weight of 2325 gm—a fat thickness equivalent to that of a full-term infant weighing nearly 1100 gm more! Several of the nine diabetic progeny exceeded the maximum fat values for the normative series of 146. Comparing the diabetic group to the normative series, using a modified sign test, the value of Chi-squared after correction for continuity was 7.1. The T-scored values similarly indicated a highly signicant fat difference between the diabetic progeny and the normal neonates.[6]

Plotting the actual fat and weight values for the diabetic series against the scattergram for the Fels newborn, the fat-to-weight relationship was even more dramatic. The diabetic progeny apparently followed the usual tendency for increased weight to parallel increased subcutaneous fat, as shown in figure 3, but suggested a greater value for the intercept *b*. In fact, there was a tendency for the two groups to separate completely, the bulk of the diabetic progeny falling above the 85th percentile for fat. With a fat/weight ratio of 1.3 as compared with 0.88 for normal neonates, it was evident that the offspring of known diabetic mothers were excessively fat for their weight, approximately 40% fatter than the progeny of putatively normal women.

DISCUSSION

The findings in this study provide a definite indication that the thickness of the subcutaneous fat can be measured reliably and profitably in the newborn, fortunately at a site with a built-in landmark that may be followed throughout life. These data, based on clinically-normal developmentally-mature white singlings, attest to the fact that fat is an extraordinarily variable "body compartment" even at birth. They further confirm the growing evidence that the female is relatively fatter

[6] Since serial antero-posterior chest x-rays were not available for the nine diabetic progeny, it is impossible to rule out the chance that the measured thickness of LT fat was to some extent exaggerated by fluid accumulation. However, excellent differentiation between the fat-plus-skin shadow and the remaining soft tissue made it less likely that the measurements were highly affected by oedema.

than the male at all developmental horizons so far investigated. The tendency for the female neonate to gain weight less rapidly than the male neonate which is true for white and Negro infants alike (*cf.* Kasius *et al.*, '57) may in part be explained by her greater developmental maturity and relatively more ample fat reserves at birth.

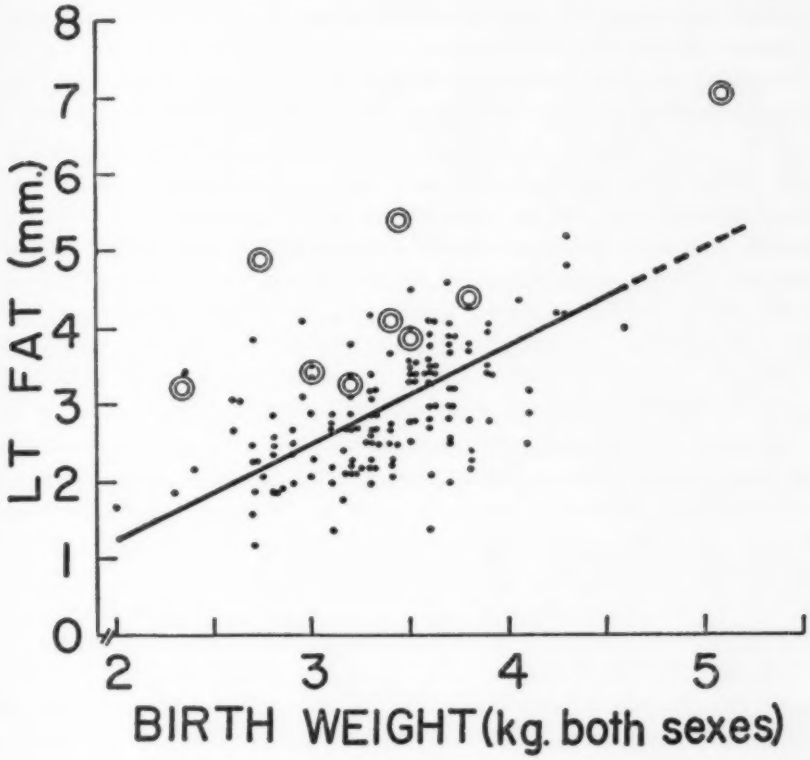

FIG. 3. NINE DIABETIC PROGENY (DOUBLE CIRCLES) PLOTTED ON THE COMBINED-SEX FAT-WEIGHT SCATTERGRAM FOR 146 FELS NEONATES. THOUGH THE MEDIAN WEIGHTS FOR THE NORMAL AND DIABETIC PROGENY WERE ALMOST IDENTICAL, THE OFFSPRING OF DIABETIC MOTHERS WERE NOTABLY FATTER FOR THEIR WEIGHT.

Within the normal variables considered in the present investigation, we have not been able to find evidence as to why one infant is fatter than another at the time of birth. Parental size, especially the fat-free mass of the mother, relates to both size and weight in the newborn, but neither maternal size nor weight gain during pregnancy significantly

bear on differences in subcutaneous fat. Naturally, these findings do not contradict the evidence that *extreme* caloric deprivation does limit birth size (*cf.* Antonov, '47; Smith, '47), nor do they deny that infants carried to term and beyond may be fatter than those prematurely born. Rather, these negative findings indicate the need for a further investigation of the very suggestive evidence that the degree of fetal activity during later pregnancy may affect the extent of fat stored by the fetus *in utero* (Sontag, '40).

Clearly, fat babies are bigger babies; they weigh more and they are larger. Both upper and lower limbs of fat neonates tend to be longer, and this trend toward great length is shared by the axial skeleton as well. Yet the correlations are low; there are fat small infants, and lean large infants. As is true during the whole period of postnatal growth and and development, the fat-size relationship while positive does not give the impression that calories stored in the form of fat are readily mobilized for increased growth and a markedly augmented rate of development. In other words, one wonders why calories are stored in the form of fat, at a time when they could be most profitably used to speed ossification, protein-synthesis and general growth.

Inclusion of the diabetic progeny does bring in one variable that bears on relative fatness. Though carried to term in only one instance, all nine of the offspring of known diabetic mothers were above the norm for fat; all were exceptionally fat in relation to their weight. While an increase in available sugar is a likely explanation for the increased fat storage in the diabetic progeny, the complexity of fat metabolism and the varying endocrine abnormalities grouped under the diagnostic entity of "diabetes" indicate the need for caution in accepting the sugar hypothesis. At the same time, it may well be that fat infants are an indication of a diabetic or pre-diabetic state on the part of the mother, a possibility that can be tested by the glucose-tolerance test.

SUMMARY

1. The thickness of the fat-plus-skin shadow at the level of the 11th rib was measured on antero-posterior "birth" x-rays of 146 Ohio-born white infants, and investigated in relation to maternal size, gestation length, body size and long-bone length.

2. As with other fat sites analyzed to date, the distribution of LT fat was markedly skewed. While there was no sex difference in the

thickness of fat, the fat/weight ratio for female neonates was significantly higher than in the male.

3. Unlike birth size and birth weight which were positively and significantly correlated with maternal size, the rate of maternal weight gain, etc., fat thickness at birth was not significantly related to maternal size, weight gain or the length of gestation.

4. Fat thickness was moderately related to birth weight in both sexes ($r = 0.6$ to 0.7), and length, femoral and tibial length and spine length (T_1-L_5) to a lesser degree ($r = 0.2$ to 0.4). Fatter babies were longer overall, and in consequence of increased fatness and greater length tended to weigh more.

5. Those neonates who were fatter at birth, tended to be fatter and longer during the first few months of postnatal life, but gained less weight during early extrauterine existence.

6. Analysis of fat-weight data on a series of nine diabetic progeny revealed that the diabetic infants were extremely fat, exceptionally so in relation to their weight, despite the fact that they had been delivered well before term.

7. These findings indicated that subcutaneous fat could be invesgated roentgenogrammetrically at the earliest age levels, and with anticipation of useful findings on the fat "compartment" and its implications in terms of late prenatal development.

8. Attention was drawn to available sugar as one possible determinant of birth fat, and to variations in fetal activity as a second variable possibly affecting fat storage in the late prenatal period.

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HAND CLASPING IN DIFFERENT ETHNIC GROUPS *

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INTRODUCTION

GENETIC traits with high but variable frequencies in different populations are especially useful in evaluating and analyzing evolutionary forces. These traits may also have considerable anthropological interest in situations where classification of a population is desired. The search for genetic characters which are common in populations may be, then, highly rewarding.

The present paper will review the work of several authors on the familial and population aspects of hand clasping and will show, with data obtained in Brazil, how this trait can be used in population studies.

REVIEW OF THE LITERATURE

When an individual clasps his hands one of two mutually exclusive events occurs: either the right (situation R; see fig. 1 in Rothschild, '30) or the left thumb (situation L; see fig. 2 in Winchester, '51) emerges uppermost.

The first person to study this trait was Lutz ('08), in a random sample of families obtained in Scotland. His data suggested the presence of a genetic component, but no simple genetic mechanism fit the data. No sexual bimodality in the trait, nor reproductive selection, nor assortative mating, nor relation to handedness was found. Early manifestation of the trait was noted, and the thumb position was quite constant even in very young children. R individuals were found to be in the majority in the parental (59%) as well as in the filial generation (60%).

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The second paper to deal with this subject (Downey, '26) was based on American data, and was more concerned with the relation between the trait and handedness. In a non-random sample (including a high proportion of ambidextral and left-handed individuals), Downey confirmed that *R* persons are the majority (51%) but failed to support Lutz's conclusion regarding the independence of hand clasping and handedness.

Dahlberg ('26) determined the incidence of the trait in a series of 69 pairs of monozygotic and 123 pairs of dizygotic twins, and found no evidence of genetic factors. The examination of 854 school children revealed a frequency of 49.9% *R*. On the basis of these two series of data, Dahlberg concluded that "there is hardly reason to presume heredity."

Wiener ('32) studied a series of American families and confirmed the finding that *R* persons are more common (54%), and that the trait is not associated with sex or handedness. His data failed to support the hypothesis of heredity proposed by Lutz to account for the heterogeneity among the children of the different types of matings, thus confirming Dahlberg's conclusion.

Data obtained in Japan and Korea by Yamaura ('40) strongly supported the genetic hypothesis, and again *R* individuals were the more common (55% in both samples). The different frequencies detected in the sexes were ascribed to errors of sampling.

The extensive material collected in Japan by Kawabe ('49) support the notion that the trait is heritable. No clear mode of inheritance, however, could be deduced from the data. *R* individuals were the more common in all his sub-samples (with an average frequency of 64%), and no statistically significant differences were found between males and females. Kawabe's data suggest that there is some degree of association between the trait and other manual actions, and that the incidence of *R* is higher among people more than 20 years old (62% against 57%). This finding confirmed the report of Rothschild ('30), who found 48% *R* among adults and 43% *R* among children in Germany. Rothschild's and Dahlberg's data are the only data in the literature which show frequencies of *R* below 50%. Kamm ('30) and Ludwig ('32) found 50% *R* in Germany.

TABLE 1

Frequencies of R individuals among the children of the three types of matings, with statistical analysis of the distributions and calculations of the frequency (q) of the allele responsible for the R trait on the basis of Trankell's ('55) model.

Data I (original), II (from Lutz, '08), III (from Wiener, '32), IV (from Yamaura, '40), and V (from Kawabe, '55).

	CHILDREN				
	R				
PARENTS ‡	*n*	%	TOTAL	*q*	x^2 †
I. $R \times R$	156	69.96	223	.9448 *	*1.* 11.95 ($P<.01$); *2.* 6.60 ($P<.02$); *3.* 5.50
$R \times L$	108	57.75	187	.9455 *	($P<.02$); *4.* 9.37 ($P<.01$); *5.* 2.93 ($P>.05$);
$L \times L$	27	48.21	56	.9473 *	*6.* 1.59 ($P>.20$); 7. 10.28 ($P<.01$).
II. $R \times R$	166	72.49	229	.9100	*1.* 30.58 ($P<.01$); *2.* 13.45 ($P<.01$); *3.* 17.67
$R \times L$	147	56.54	260	.9104	($P<.01$); *4.* 28.98 ($P<.01$); *5.* 2.34 ($P>.10$);
$L \times L$	46	42.20	109	.8996	*6.* 6.33 ($P<.02$); 7. 23.99 ($P<.01$).
III. $R \times R$	76	53.52	142	.9960	
$R \times L$	131	55.98	234	$\sqrt{-649.74}$	*1.* 3.15 ($P>.20$)
$L \times L$	42	45.16	93	.9407	
IV. $R \times R$	112	70.44	159	.8895	*1.* 30.34 ($P<.01$); *2.* 12.66 ($P<.01$); *3.* 18.02
$R \times L$	110	52.13	211	.9156	($P<.01$); *4.* 28.77 ($P<.01$); *5.* 2.15 ($P>.10$);
$L \times L$	21	31.82	66	.8643	*6.* 8.32 ($P<.01$); 7. 21.93 ($P<.01$).
V. $R \times R$	594	77.75	761	.9101	*1.* 176.15; *2.* 56.81; *3.* 124.56; 4. 169.38;
$R \times L$	244	57.28	426	.9192	*5.* 14.62; *6.* 40.49; 7. 131.90; ($P<.01$).
$L \times L$	62	30.24	205	.8698	

* Assuming *L* to be due to a recessive gene, the gene frequencies for each group of parents, according to Trankell's model, would be .8515, .7602, and .8130 respectively. The probability that the first value would fit all the family data is less than .01; for the second, $P<.05$; for the third, $P>.20$. The hypothesis cannot be assumed to explain the whole family information.

† *1* refers to x^2 for $(R \times R)$vs$(R \times L)$vs$(L \times L)$; *2* to $(R \times R)$vs$(R \times L)$; *3* to $(R \times R) + (R \times L)vs(L \times L)$; *4* to $(R \times R)$vs$(L \times L)$; *5* to $(R \times R) + (L \times L)vs(R \times L)$; *6* to $(R \times L)$vs$(L \times L)$; 7 to $(R \times L) + (L \times L)vs(R \times R)$.

‡ The three classes of families in each set of data will be referred as a, b, and c respectively in the next Table.

ORIGINAL DATA AND DISCUSSION

Family data

The first section of table 1 presents the frequency of R children in a Brazilian sample of the three types of matings (parents $R \times R$, $R \times L$, and $L \times L$). The class $R \times L$ includes data from $\varphi R \times \sigma L$ and $\varphi L \times \sigma R$; no statistically significant differences were found between these matings (56 R and 44 L among the children of $\varphi R \times \sigma L$, and 52 R and 35 L among the children of $\varphi L \times \sigma R$; $X^2 = .27$, $DF = 1$, $P > .50$). The latter observation holds true for the data of Lutz ('08), ($X^2 = .09$, $DF = 1$, $P > .70$), Wiener, 1932 ($X^2 = .03$, $DF = 1$, $P > .80$), and Kawabe, 1949 ($X^2 = .18$, $DF = 1$, $P > .50$). Yamaura ('40) does not differentiate between these two types of matings. X^2 for heterogeneity among the three types of Brazilian matings (table 1) is 11.95 ($DF = 2$, $P < .01$). Partition of this X^2 (see table 1) reveals that the children of parents $R \times L$ have frequencies of R identical to those found among the children of $R \times R$ and $L \times L$ combined (a fact also seen in the data of Lutz, '08, and Yamaura, '40, but not of Kawabe, '49). Our data also show that the differences between the children of $R \times L$ and $L \times L$ are not significant, an observation not confirmed by the above authors who found significant differences. All the other comparisons in our data show significant differences.

Wiener's data ('32) differ from those of Lutz, Kawabe, Yamaura, or our own in that no significant differences between the various mating types were found. A clear suggestion of a parent-offspring correlation in hand-clasping type is found in all data save Wiener's. In the absence of a psychological explanation of the findings, it is our opinion that some prenatal factor (probably genetic in nature) is responsible for the trait. No simple Mendelian hypothesis is capable, however, of explaining the findings.

We have applied a genetic model suggested by Trankell ('55) to our data as well as to those presented by Lutz, Wiener, Yamaura, and Kawabe (*cf.* table 1). The model is that R is due to a recessive gene (r), but that a certain fraction of rr individuals are phenotypically L; the opposite hypothesis (that L individuals are homozygous for a recessive gene (l), but some ll individuals are phenotypically R) does not fit our data (see footnote to table 1). Three of the 5 sets of data (Lutz's, Yamaura's, and our own) give results compatible with the first model, but Kawabe's data does not (*cf.* statistical analysis in table 2).

Wiener's data lead to an absurd result (table 1). No conclusions can be drawn from the analysis based on Trankell's model.

The frequencies (in per cent) of the 4 types of matings ($R \times R$, ♀ $R \times$ ♂ L, ♀ $L \times$ ♂ R, and $L \times L$) in our data are, respectively, 47.80,

TABLE 2

Statistical analysis of some values of q in each set of data presented in Table 1, according to Trankell ('55).

	Family *a* † Children		Family *b* † Children		Family *c* † Children			
q	*R*	*L*	*R*	*L*	*R*	*L*	x^2	*P*
I * →	156	67	108	79	27	29		
.94	157.6	65.4	106.9	80.1	25.9	30.1	.1687	.50-.70
.95	154.3	68.7	108.8	78.2	27.4	28.6	.0863	.70-.80
II →	166	63	147	113	46	63		
.90	169.7	59.3	145.5	114.5	46.1	62.9	.3470	.50-.70
.91	166.0	63.0	147.0	113.0	48.0	61.0	.1489	.70
IV →	112	47	110	101	21	45		
.86	119.8	39.2	102.1	108.9	20.5	45.5	3.2619	.05-.10
.89	111.9	47.1	106.7	104.3	24.0	42.0	.7961	.30-.50
.91	107.0	52.0	109.3	101.7	26.3	39.7	2.4993	.10-.20
.92	104.7	54.3	110.5	100.5	27.5	38.5	4.1289	.02-.05
V →	594	167	244	182	62	143		
.87	650.1	110.9	216.7	209.3	62.1	142.9	40.2203	<.01
.91	594.2	166.8	239.5	186.5	83.0	122.0	9.1214	<.01
.92	581.3	179.7	244.4	181.6	88.3	116.7	14.9370	<.01

* Numbers I, II, IV and V as in table 1.

† *a*, *b* and *c* correspond respectively to the three classes of families described in table 1.

22.64, 18.87, and 10.69 ($N = 159$). These frequencies do not differ significantly from those expected on the basis of random mating ($X^2 = .24$; $DF = 3$, $P > .95$). The 4 classes of parents have had the following average numbers of children: $2.93 \pm .21$, $2.78 \pm .29$, $2.90 \pm .38$, and $3.29 \pm .50$, respectively. These differences are not statistically significant.

The frequencies of R children by birth order in the pooled data are

60% among first born children ($N = 62$), 45% among second born ($N = 51$), 63% among third born ($N = 30$), and 61% among fourth born and the following children ($N = 33$). There is no significant birth rank effect ($X^2 = 3.74$, $DF = 3$, $P > .20$).

FIG. 1. STATES (IN ITALIC) AND LOCALITIES WHERE THE DATA HAVE BEEN COLLECTED. 1. *Pernambuco*, PESQUEIRA; 2. *Sergipe*, ARACAJU; 3. *Bahia*, a. BARRA DO RIO GRANDE, b. SANTO AMARO, c. SALVADOR; 4. *Federal District*, RIO DE JANEIRO; 5. *São Paulo*, a. PRESIDENTE PRUDENTE, b. SÃO PAULO; 6. *Paraná*, a. LONDRINA, b. CASTRO, c. CURITIBA, d. MANGUEIRINHA, e. PALMAS; 7. *Santa Catarina*, XAPECÓ.

Population data

Table 3 presents a series of samples drawn from several different Brazilian populations (see also fig. 1). These samples consist of

TABLE 3

Frequencies of R individuals in different localities and ethnic groups in Brazil

LOCALITIES AND ETHNIC GROUPS	SAMPLE SIZE	INDIVIDUALS *R*	
		n	%
Rio de Janeiro, DF (C, S)			
Caucasians	827	454	54.90
Mulattoes	531	317	59.70
Negroes	98	63	64.29
Total	1,456	834	57.28
São Paulo, SP (C, S)			
Caucasians	582	320	54.98
Mulattoes	107	62	57.94
Negroes	36	28	77.78
Total	725	410	56.55
Mongoloids (J, C)	375	215	57.33
Salvador, Ba (C, Ne, S)			
Caucasians	157	90	57.32
Mulattoes	439	283	64.46
Negroes	355	245	69.01
Total	951	618	64.98
Londrina, Pr (C, S)			
General sample (W)	237	142	59.92
Mongoloids (J)	637	398	62.48
Palmas and Xapecó, Pr (A)			
Caingang Indians	167	88	52.69
Mangueirinha, Pr (A)			
Guarani Indians	25	17	68.00
Curitiba, Pr (C, W)	1,502	851	56.66
Castro, Pr (C, W)	308	187	60.71
Presidente Prudente, SP*, (A, H)	146	90	61.64
Barra do Rio Grande, Ba (C,ne)	220	148	67.27
Santo Amaro, Ba (C, Ne)	91	66	72.53
Aracaju, Se (C, W)	146	76	52.05
Pesqueira, Pe (C, W)	476	259	54.41
Total of Caucasians	1,566	864	55.17
Total of Mulattoes	1,077	662	61.47
Total of Negroes	489	336	68.71
Total of Indians	192	105	54.69
Total of Mongoloids	1,012	613	60.57
GRAND TOTAL	7,462	4,399	58.95

A—mainly adults; C—mainly or exclusively school children; H—highly heterogeneous sample from the ethnic view-point; J—Japanese stock; Ne—mainly Negroes and Mulattoes (frequencies higher than 80%); ne—43% Negroes and Mulattoes; W—mainly Caucasians; * including also a few data obtained in neighboring localities; S—samples not representative of the whole population, since they have been obtained in wards showing high frequencies of Negroes and/or Mongolians.

unrelated individuals. The main conclusions to be drawn from these data are the following:

I. *R* individuals are the more frequent in all samples. This has been previously reported by Aguiar and Freire-Maia ('53).

II. Analysis of the total Negro, Mulatto, and Caucasian samples reveals significant heterogeneity ($X^2 = 31.11$, $DF = 2$, $P < .01$). Similar analysis of the subsamples from Salvador, São Paulo, and Rio de Janeiro yield X^2 equal to 6.63 ($P < .05$), 7.27 ($P < .05$), and 5.15 ($P > .05$), respectively. Negroes show frequencies of *R* (68.71% in the total) significantly higher ($X^2 = 28.11$, $DF = 1$, $P < .01$) than Caucasians (55.17% in the total). The Mulatto subsamples exhibit intermediate frequencies, as expected (61.47% in the total).

III. The differences between 11 localities and two racial groups given in table 3 (obtained by using the total from each locality and pooling the data on Mongolians and Indians into two groups irrespective of the locality from whence they come) are highly significant ($X^2 = 44.59$, $DF = 12$, $P < .01$). This X^2 value is, however, largely due to the three samples from the state of Bahia (Salvador, Santo Amaro, and Barra do Rio Grande); their contribution to the total X^2 is 27.53. This is probably due to the high frequencies of Negroes and Mulattoes in these areas (70% in Bahia according to the 1950 Census). Upon removal of these three samples, the remaining samples are homogeneous ($X^2 = 11.78$, $DF = 9$, $P > .20$).

IV. The differences between the three Caucasian groups ($X^2 = .33$, $DF = 2$, $P > .80$), between the three Mulatto groups ($X^2 = 2.93$, $DF = 2$, $P > .20$), between the three Negro groups ($X^2 = 2.28$, $DF = 2$, $P > .30$), between the two Indian groups ($X^2 = 2.06$, $DF = 1$, $P > .10$), and between the two Mongolian subsamples ($X^2 = 2.62$, $DF = 1$, $P > .20$) are not significant. The subsamples within each ethnic group have been pooled to form larger samples for intergroup comparisons. The differences between Indians and Caucasians ($X^2 = 0.02$, $DF = 1$, $P > .80$), Indians and Mulattoes ($X^2 = 3.13$, $DF = 1$, $P > .05$), Indians and Mongolians ($X^2 = 2.32$, $DF = 1$, $P > .10$) are not significant, but that between Indians and Negroes is highly significant ($X^2 = 11.88$, $DF = 1$, $P < .01$). The differences between Mongolians and Caucasians ($X^2 = 7.33$, $DF = 1$, $P < .01$) and between Mongolians and Negroes ($X^2 = 9.39$, $DF = 1$, $P < .01$) are highly significant, but that between Mongolians and Mulattoes ($X^2 = .18$, $DF = 1$, $P > .50$) is not significant.

V. One sample of 1,143 children and teen-age boys and girls (53% *R*) obtained in elementary and high schools in two localities, Curitiba and Castro, in the state of Paraná, is significantly different ($X^2 = 27.84$, $DF = 1$, $P < .01$) from a sample of 403 adults from the same areas (68% *R*). Analysis of these data, taking sex into account, yields similar results. Thus, among 351 females, 60% of 186 children and 70% of 165 adults were *R* ($X^2 = 3.91$, $DF = 1$, $P < .05$), and among 1,138 males, 52% of 900 children and 67% of 238 adults were *R* ($X^2 = 17.17$, $DF = 1$, $P < .01$). These findings with respect to sex are in agreement with those of Kawabe ('49), who detected a significant difference among individuals above and below the age of 20 years (see also Rothschild, '30).

The Caucasian fraction of the non-adult sample obtained in Curitiba (which forms a large part of the above-mentioned sample from the State of Paraná) has been subdivided according to age into three groups (8–12, 13–16, and 16–20). The frequencies of *R* individuals in these groups were 54%, 53%, and 48% respectively. These differences are not significant ($X^2 = 2.22$, $DF = 2$, $P > .30$). No significant difference has been found in a sample of 926 children from Salvador, Ba, classified into three groups according to age (7–9, 10–12, and 13–16) with 68%, 63%, and 66% *R* respectively ($X^2 = 2.12$, $DF = 2$, $P > .30$). The analysis within each of the three ethnic components of the whole Salvador sample also failed to reveal an age effect.

VI. An analysis of the incidence of *R* individuals among males (56%) and females (61%) shows a highly significant difference in a total of 4,882 individuals including Caucasians, Mulattoes, and Negroes ($X^2 = 15.95$, $DF = 1$, $P < .01$). Within each of the ethnic subsamples, the sex differences are significant only among Caucasians (53% in males and 57% in females; $N = 3{,}040$; $X^2 = 5.61$, $DF = 1$, $P < .02$). Among Negroes and Mulattoes the same excess of *R* among females occurs, however (73% versus 65% in Negroes, $N = 489$; and 64% versus 60% in 1,353 Mulattoes). Among 190 Indians, 948 Mongolians, and 403 adults mostly Caucasians from Paraná, the excess of *R* females also proves to be not significant. A significant sex difference does occur in a predominantly Caucasian sample of 1,086 children from Paraná (52% in males and 60% in females; $X^2 = 4.41$, $DF = 1$, $P < .05$). No sex effect has been found by the other authors who have studied this trait, but the consistency of the excess of *R* females among all of the comparisons in our data leads us to believe that the sexes do differ in the frequencies of this trait.

VII. Since the frequencies of the two forms of the trait in different samples are influenced not only by the ethnic composition of the sample but probably also by the age and sex distribution of the individuals involved, it is hazardous to compare samples obtained by different authors unless the above characteristics are clearly specified. These characteristics are not sufficiently specified in the data available in the literature to permit more than a rough comparison of our data with those in the literature. Our Caucasian samples, for instance, with 55% *R* are intermediate between those from Germany and Sweden (50% and less) and those from Scotland (parents in Lutz's family data, 60%), and are identical with the American data reported by Wiener. Our Mongolian samples, with 61% *R*, are roughly comparable to the three Japanese samples of Kawabe (60%, 64%, and 65%) but are unlike Yamaura's sample from Japan and Korea (55%).

SUMMARY

Family data show some parental influence on the type of hand clasping encountered among their children. A prenatal factor (probably genetic in nature) is suggested as the explanation of this correlation. No simple Mendelian mechanism seems to account for the data, however. The four types of matings occur with the frequencies expected from random mating, and the four mating types appear equi-fertile. Birth order exerts no effect on the type of hand clasping.

Population data show that Negroes and Caucasians, Caucasians and Mongolians, and Mongolians and Negroes differ in the frequencies of the two types of hand clasping. Among Mulattoes, the frequencies are intermediate between Caucasians and Negroes, as expected. No other significant difference has been detected among the various ethnic samples. Adults have a higher frequency of the "right thumb" type than children, and females a higher frequency than males.

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HEIGHT AND WEIGHT OF SELECTIVE SERVICE REGISTRANTS PROCESSED FOR MILITARY SERVICE DURING WORLD WAR II

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INTRODUCTION

THE height and weight findings presented here relate to Selective Service registrants examined for military service during the thirteen-month period from January 1943 through January 1944. Somewhat over 5.5 million men, 18 through 37 years of age, were examined during this period by the Joint Army and Navy Induction Stations.

Each registrant arriving at an induction station was ordinarily given a complete medical examination in order to determine his acceptability for military service. The results of the examination were recorded on DSS Form 221 ("Report of Physical Examination and Induction") which, in addition to the clinical evaluation of the registrant's medical (physical and psychiatric) status, included related laboratory (x-ray findings, serologic tests for syphilis, etc.) and anthropometric data (height, weight).

The induction stations were required to submit a copy of these physical examination forms to the office of The Surgeon General, Army, for: *a*. Each examined registrant who was disqualified for military service, and *b*. each qualified examinee assigned to the Army. During this period about three-fourths of the qualified registrants called for induction were assigned to the Army and about one-fourth to the Navy. Copies of the physical examination forms for Navy inductees were not available to The Surgeon General's Office, Army. Adjustments, explained later, were made for this partial coverage of the inducted registrants, in order to reflect the total examined registrant population.

Out of the total number of the physical examination forms received during this period a ten-percent random sample was drawn by choosing a single terminal digit of the Selective Service number assigned to the registrant by his local board, as recorded on the forms. The punch-cards, to which the height-weight data obtained from the sample were transferred, contained pertinent personal items, such as the examinee's occupation, place of residence, age, race, etc., and related medical data.

About 465,000 medical examination forms were included in the study. A distribution of these forms by age, race, and military qualification (inducted or disqualified) of the examinees involved in the study is shown in table 1. Age is given as of last birthday. The term "white" used in the racial classification refers to non-Negro. The data relate to examinees of known height and weight, as well as of known age and race.

HEIGHT AND WEIGHT MEASUREMENTS

The examinees were measured without their shoes and weighed without clothing. Height was recorded in inches, and weight in pounds, as specified on the physical examination forms.

Specific instructions with respect to measuring height have been provided by the regulations on physical standards (Mobilization Regulations 1-9, '42) which read as follows:

> "Use a board at least 2 inches wide by 80 inches long, placed vertically and carefully graduated to $\frac{1}{4}$ inch between 58 inches from the floor and the top end. Obtain the height by placing vertically, in firm contact with the top of the head, against the measuring rod an accurately squared board of about 6 by 6 inches, best permanently attached to graduated board by a long cord. The individual should stand erect with back to the graduated board, eyes straight to the front."

An examination of the physical examination forms revealed that ordinarily height was recorded in whole inches, though it was given sometimes to a half or quarter inch. Recorded fractions of inches were dropped in coding the height data.

Weight was presumably taken to the nearest pound. Fractions of pounds appearing on the forms were disregarded, and the weight was coded in whole numbers, as in the case of height.

TABULATION OF DATA

In tabulating the height and weight data, the qualified (inducted) and disqualified examinees were treated separately. This was done for two reasons: First, it was important from a military point of view to obtain separate height and weight data on individuals qualified for military service; second, anticipated differences in the height and weight of these groups suggested adjustments for the under-presentation of the qualified group—due to the unavailability of the physical examination forms of Navy inductees—in combining these data for inducted and disqualified examinees. (See following section: Adjustments for Disproportionality.)

TABLE 1

Number of physical examination forms included in the sample study of height and weight, by age, race, and military qualification of the examinees (January 1943 through January 1944) *

AGE	WHITE		NEGRO	
	Inducted	Disqualified	Inducted	Disqualified
18–19	77,744	32,507	9,171	6,968
20–24	67,824	29,971	11,559	9,572
25–29	40,934	28,971	6,661	9,446
30–34	34,567	34,225	5,407	10,897
35–37	16,303	22,891	2,535	6,422
Total (18–37)	237,372	148,565	35,333	43,305

* Source: Sample tabulations of DSS Form 221 ("Report of Physical Examination and Induction").

Weight by height was cross-tabulated for each of these groups, as follows: *a.* By age and race, *i. e.*, for each subgroup, as given in table 1; *b.* by geographic region and race; *c.* by size of community and race, and *d.* by occupation and race.

ADJUSTMENTS FOR DISPROPORTIONALITY

Because of differences found between the height and weight values of the qualified (inducted) and those of the disqualified groups, direct additions of the height and weight distributions of these groups—for the purpose of obtaining corresponding distributions and derived values (means, standard deviations, etc.) for the combined (inducted plus disqualified) groups—would obviously have introduced certain bias in the

calculations by giving undue weight to disqualified groups. To correct for these disproportionalities, the cross-tabulated weight-height data of the qualified (inducted) examinees were proportionally increased, before combining these with the corresponding data for the disqualified groups. These adjustments were made within the height-range of 62 through 76 inches—the acceptable height-range for Navy inductees. (For Army inductees, the acceptable height-range was from 60 through 78 inches.)

In making these adjustment, it was assumed that within this adjusted height-range, the Navy inductees were distributed by height and weight as the Army inductees, as no other factors related to height or weight played a decisive part in the assignment of qualified registrants to the Army or the Navy. (See: "Appendix: Technical Notes," par. 2: Adjustment Factors.)

REPRESENTATIVENESS OF THE DATA

Limited to registrants examined at the induction stations, these height and weight data excluded registrants disqualified by the local boards prior to the induction processing, as well as deferred and exempt registrants. During this period the local boards played a minor role in the screening of registrants for military service, so that the exclusion of registrants disqualified by the local boards could not have produced an appreciable distorting effect on the height and weight data. As to the deferred and exempt registrants, there is no reason to believe that their distributions by height and weight differed materially from that of the other registrants. There are indications that such differences would be primarily a function of age. But these differences have been essentially eliminated by the fact that the height and weight values were derived by age.

With the above-mentioned adjustments for disproportionality, the height and weight distributions and the derived height and weight values presented here may be reliably regarded as representative of all registrants, by age and race, within the (18–37) age range.

FREQUENCY DISTRIBUTIONS OF HEIGHT AND WEIGHT AND THEIR QUARTILE VALUES

As first step in the analysis of the data, two basic tables (tables 2-3) are presented. Table 2 shows distributions of the examined registrants by height, in terms of age and race; table 3 shows corresponding distributions by weight. (Similar distributions are available for inductees alone.)

TABLE 2

Percent Distribution of Selective Service registrants examined for military service by height, age, and race

(January 1943 through January 1944)

HEIGHT IN INCHES		PERCENTAGE DISTRIBUTION, BY AGE									
		WHITE					NEGRO				
As Tabulated	Mid-values	18–19	20–24	25–29	30–34	35–37	18–19	20–24	25–29	30–34	35–37
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
<60	58.9	0.08	0.07	0.10	0.15	0.21	0.13	0.11	0.11	0.14	0.22
60	60.2	0.20	0.19	0.20	0.32	0.35	0.31	0.22	0.27	0.34	0.39
61	61.2	0.47	0.41	0.48	0.62	0.72	0.77	0.61	0.64	0.75	1.00
62	62.2	1.13	1.08	1.19	1.55	1.97	1.60	1.37	1.43	1.69	1.90
63	63.2	2.62	2.30	2.39	3.04	3.63	3.00	2.84	2.89	3.56	3.92
64	64.2	4.84	4.60	4.82	5.78	6.55	6.33	5.49	5.19	6.06	6.84
65	65.2	8.36	7.87	8.38	9.23	10.14	10.11	9.24	8.99	9.74	10.21
66	66.2	12.16	11.46	11.72	12.29	12.78	13.79	12.40	12.77	12.98	13.76
67	67.2	14.72	14.59	14.78	15.05	15.51	15.40	15.00	15.03	15.22	15.12
68	68.2	15.64	15.55	15.67	15.31	14.88	14.68	15.59	15.16	15.02	13.26
69	69.2	13.96	14.28	13.86	13.25	12.46	13.07	12.88	13.45	12.43	13.27
70	70.2	10.56	11.11	10.73	9.78	8.96	9.36	9.72	9.77	9.25	8.59
71	71.2	7.28	7.83	7.48	6.65	6.04	5.76	6.86	6.90	6.17	5.92
72	72.2	4.23	4.67	4.44	3.77	3.26	3.17	4.13	4.21	3.60	3.12
73	73.2	2.12	2.27	2.11	1.77	1.40	1.52	1.97	1.66	1.69	1.29
74	74.2	0.94	1.01	0.99	0.86	0.69	0.60	0.91	0.89	0.79	0.66
75	75.2	0.43	0.41	0.38	0.33	0.26	0.25	0.32	0.36	0.31	0.30
76	76.2	0.17	0.18	0.15	0.15	0.12	0.09	0.16	0.14	0.15	0.12
77	77.2	0.05	0.07	0.07	0.05	0.03	0.02	0.10	0.07	0.06	0.07
78+	78.3	0.04	0.05	0.06	0.05	0.04	0.04	0.08	0.07	0.05	0.04
Population Bases *		135,053	119,433	82,964	79,820	44,395	17,123	22,370	16,822	16,884	9,229

* Adjusted for disproportionality. (See text.)

The distribution by height (table 2) are given in terms of one-inch intervals, as tabulated. A special study of a number of cases indicated that the heights averaged approximately two-tenths of an inch in excess of the coded (and hence tabulated) whole number of inches. (See report: Surgeon General's Office, '45.) The midvalues of the height-intervals were established accordingly. For example, the midvalue of "tabulated" 70 inches is shown in table 2 as 70.2 inches. Separate determinations were made for the midvalues of the open-end height intervals, namely, for the intervals of "under 60" and "78 and over," since these intervals were lumped. Their respective midvalues were estimated as 58.9 and 78.3 inches for all distributions.

Weight was tabulated in 5-pound intervals, and it is so presented in table 3. Since weight was supposedly recorded to the nearest pound, the midvalue, say, of the 100–104 tabulated weight-interval is shown in table 3 as 102 pounds. Examinees who weighed under 90 pounds are given in the table as one group, although their individual weights in 5-pound intervals and their frequencies were available from the tabulations. This is also true of examinees who weighed 305 pounds or more. The midvalues of these open-end weight intervals ("under 90" and "305 and over") were determined on the basis of their actual frequencies and are given in the footnotes to the weight-table (table 3).

The upper and lower limits of the height-intervals (table 2) should be taken, of course, as ∓ 0.5 inch from their midvalues (table 2), and the corresponding limits of the weight-intervals as ∓ 2.5 pounds from their midvalues (table 3).

At the bottom of each column of the tables (tables 2-3) the population base is given for the particular distribution. These population bases exceed in each case the corresponding sum of disqualified plus inducted registrants, that would be obtained from table 1, due to the corrections for disproportionality.

The height and weight distributions (tables 2-3) have been condensed in table 4 into quartile values. The following general characteristics of these values will be noted: *a.* Increase for both white and Negro examinees in the quartile values of height through the (20–24) age-interval, followed by a decline, age by age, beyond that age-interval, signifying lower heights in the advanced ages; *b.* gradual increase for white and Negro examinees in all quartile values of weight, beginning with the youngest age group, indicating larger weights with advancing age, and *c.* relatively larger quartile values of height and, generally, also of weight for white than for Negro examinees. (This is further discussed in the

Population Bases*	135,053	119,433	82,964	79,820	44,395	17,123	22,370	16,822	16,884	9,229

* Adjusted for disproportionality. (See text.)

TABLE 3

Percent distribution of Selective Service registrants examined for military service by weight, age, and race

(January 1943 through January 1944)

WEIGHT IN POUNDS		PERCENTAGE DISTRIBUTION, BY AGE									
		WHITE					NEGRO				
As Tabulated	Mid-values	18–19	20–24	25–29	30–34	35–37	18–19	20–24	25–29	30–34	35–37
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Under 90	*	0.05	0.01	0.01	0.01	0.01	0.02	—	—	0.01	—
90–94	92	0.06	0.03	0.02	0.03	0.03	0.05	0.04	0.01	0.02	0.01
95–99	97	0.24	0.11	0.09	0.10	0.15	0.16	0.09	0.05	0.06	0.12
100–104	102	0.54	0.25	0.21	0.21	0.25	0.50	0.17	0.13	0.13	0.23
105–109	107	1.34	0.72	0.55	0.53	0.59	1.10	0.46	0.36	0.36	0.44
110–114	112	2.41	1.38	1.06	1.14	1.16	2.00	1.04	0.89	0.95	1.09
115–119	117	4.14	2.64	2.02	1.95	1.94	3.88	2.03	1.66	1.93	1.68
120–124	122	6.55	4.49	3.59	3.29	3.34	6.12	3.98	3.22	2.83	2.94
125–129	127	8.64	6.51	5.15	4.75	4.41	8.83	6.17	4.90	4.76	5.08
130–134	132	10.91	9.19	7.12	6.50	6.48	11.94	8.77	7.25	7.21	6.75
135–139	137	11.11	10.00	8.15	7.35	7.34	12.04	10.45	9.21	8.74	8.95
140–144	142	11.53	10.81	9.22	8.81	8.35	12.94	12.07	10.47	9.78	9.59
145–149	147	9.69	10.14	9.17	8.77	8.22	10.89	11.77	10.73	9.91	9.68
150–154	152	8.94	10.19	9.79	9.23	8.77	10.23	12.18	12.44	11.44	10.50
155–159	157	5.93	7.29	7.61	7.32	7.38	5.97	8.22	8.43	8.00	7.92
160–164	162	4.86	6.22	6.97	7.15	7.61	4.61	6.90	7.48	7.72	7.67
165–169	167	3.38	4.71	5.74	5.99	6.05	3.11	4.93	5.87	5.98	5.93
170–174	172	2.58	3.83	5.02	5.52	5.41	1.96	3.71	4.66	4.91	4.95
175–179	177	1.73	2.68	3.93	4.39	4.46	1.23	2.21	3.52	3.51	3.93
180–184	182	1.31	2.22	3.34	3.82	4.07	0.78	1.63	2.44	2.83	3.21
185–189	187	0.93	1.52	2.49	2.77	3.07	0.46	0.94	1.60	2.16	2.51
190–194	192	0.69	1.18	2.10	2.36	2.49	0.29	0.67	1.28	1.56	1.61
195–199	197	0.52	0.93	1.50	1.77	1.97	0.20	0.38	0.77	1.24	1.31
200–204	202	0.45	0.74	1.36	1.56	1.64	0.16	0.31	0.72	1.08	1.26
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.08	0.24	0.42	0.60	0.87

185–189	187	0.93	1.52	2.49	2.77	3.07	0.46	0.94	1.60	2.16	2.51
190–194	192	0.69	1.18	2.10	2.36	2.49	0.29	0.67	1.28	1.56	1.61
195–199	197	0.52	0.93	1.50	1.77	1.97	0.20	0.38	0.77	1.24	1.31
200–204	202	0.45	0.74	1.36	1.56	1.64	0.16	0.31	0.72	1.08	1.26
205–209	207	0.31	0.49	0.86	1.13	1.19	0.08	0.24	0.42	0.60	0.87
210–214	212	0.23	0.40	0.67	0.86	0.84	0.08	0.15	0.41	0.56	0.69
215–219	217	0.19	0.29	0.49	0.63	0.68	0.07	0.08	0.24	0.41	0.37
220–224	222	0.15	0.22	0.42	0.49	0.53	0.07	0.11	0.22	0.29	0.34
225–229	227	0.11	0.18	0.32	0.33	0.35	0.02	0.06	0.13	0.28	0.24
230–234	232	0.08	0.13	0.23	0.29	0.29	0.05	0.06	0.07	0.17	0.25
235–239	237	0.07	0.11	0.16	0.20	0.20	0.01	0.06	0.12	0.11	0.23
240–244	242	0.08	0.08	0.16	0.20	0.20	0.04	0.01	0.07	0.11	0.07
245–249	247	0.06	0.05	0.11	0.10	0.12	0.02	0.04	0.04	0.08	0.08
250–254	252	0.05	0.06	0.08	0.11	0.11	0.01	0.01	0.03	0.08	0.13
255–259	257	0.03	0.04	0.05	0.09	0.07	0.02	0.03	0.07	0.02	0.05
260–264	262	0.02	0.04	0.06	0.05	0.06	0.01	—	0.01	0.04	0.03
265–269	267	0.02	0.02	0.05	0.05	0.04	0.01	0.00	0.01	0.03	0.05
270–274	272	0.01	0.02	0.03	0.03	0.03	0.01	0.01	—	0.04	0.07
275–279	277	0.01	0.01	0.03	0.03	0.02	—	—	0.01	0.02	0.03
280–284	282	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.01	—	0.03
285–289	287	0.01	0.01	0.02	0.01	0.01	—	—	0.01	—	—
290–294	292	0.01	0.01	0.01	0.01	0.02	—	0.00	0.01	0.01	—
295–299	297	0.00	0.01	—	0.00	0.01	0.01	0.01	—	0.01	0.01
300–304	302	0.01	0.01	0.01	0.01	0.02	—	—	0.01	0.01	—
305 & Over	*	0.01	0.01	0.01	0.03	0.01	0.01	—	0.02	0.01	—
Popuiation Bases **		135,053	119,433	82,964	79,820	44,395	17,123	22,370	16,822	16,884	9,229

* *White.* *a.* For under 90, by age: (18–19)—84.5 pounds; (20–24)—85.0 pounds; (25–29)—86.0 pounds; (30–34)—83.0 pounds; (35–37)—86.0 pounds;

b. For 305 and over, by age: (18–19)—322.6 pounds; (20–24)—317.1 pounds; (25–29)—315.2 pounds; (30–34)—326.0 pounds; (35–37)—338.0 pounds

Negro. *a.* For under 90, by age: (18–19)—80.5 pounds; (30–34)—87.0 pounds; *b.* For 305 and over, by age: (18–19)—332.0 pounds; (25–29)—323.5 pounds; (30–34)—317.0 pounds.

** See footnote to table 2.

following section on the mean heights and weights and their modal values.) As might have been expected, the median height-values were found to be the same as their respective mean values due to the normality of their distributions, while the median weight-values were found to be different from their respective mean values because of their skewed distributions (table 4).

TABLE 4

Quartile values of height and weight of Selective Service registrants examined for military service, by age and race (January 1943 through January 1944)

AGE	QUARTILE VALUES					
	White			Negro		
	First	Second (Median)	Third	First	Second (Median)	Third
	HEIGHT (INCHES)					
Total: Ages (18–37)	66.2	68.0	69.7	66.0	67.7	69.5
18–19	66.3	68.0	69.8	65.9	67.6	69.4
20–24	66.4	68.2	69.9	66.1	67.9	69.6
25–29	66.3	68.1	69.8	66.1	67.9	69.6
30–34	66.1	67.8	69.6	65.9	67.7	69.5
35–37	65.8	67.6	69.4	65.7	67.5	69.3
	WEIGHT (POUNDS)					
Total: Ages (18–37)	134.3	147.3	163.1	135.5	147.3	160.3
18–19	130.0	141.2	153.9	130.5	140.8	151.7
20–24	134.3	146.4	160.5	135.6	146.5	158.0
25–29	137.7	151.4	168.2	138.0	149.9	163.0
30–34	138.9	153.1	171.2	138.4	150.9	165.5
35–37	139.0	153.9	172.2	138.6	151.6	167.2

MEAN HEIGHTS AND WEIGHTS AND MODES OF WEIGHT

Heights. The mean heights of the examined registrants are shown in table 5, by age and race. As these data indicate, the (20–24) age-group—age of maturity—had the highest stature. The younger, the (18–19) age-group—still a growing group—and all the age-groups beyond the (20–24) age-group had lower mean heights. This holds for both white and Negro examinees.

For white examinees, the mean heights were as follows: 68.06; 68.19; 68.09; 67.83, and 67.59 inches, for the (18–19), (20–24), (25–29), (30–34), and (35–37) age groups, respectively. For Negro examinees,

the mean heights were 67.64; 67.91; 67.90; 67.70, and 67.51 inches, for the corresponding age-groups within the (18–37) age-range.

The decrease in mean heights beyond a certain age had been often ascribed to physiologic changes occurring after the individuals had reached skeletal maturity. When so exclusively explained, sight is lost of the secular trend of increasing height as a contributing factor, with the older age-groups being originally of lower stature.

In comparing heights by race, the white examinees appeared on the average between 0.1 and 0.4 of an inch taller than the Negro examinees. The greatest differences were in the younger age-groups.

Alongside with the mean heights, the standard deviations—measures of absolute variability, and the coefficients of variation—measures of relative variability—are shown in table 5. The functions of these values as an index of "clustering" about the mean are too known to require elaboration. For both white and Negro examinees, the standard deviations of height fluctuated around 2.6 or 2.7 inches, and the coefficients of variation around 3.8 and 4.0 percent. These values tend to increase with age, imparting increasing variability with advanced age. There were no material differences in the variability of heights, by race.

The modes of height, like its medians, proved to be practically the same as the corresponding mean heights. No separate modal values of height are therefore shown.

Weight. For white examinees, the mean weights by age were: 143.7; 149.3; 154.8; 156.7, and 157.3 pounds for the (18–19), (20–24), (25–29), (30–34), and (35–37) age-groups, respectively. For Negro examinees, the mean weights by age were: 141.8; 147.9; 152.0; 153.7, and 154.7 pounds for the same age-groups as given for white examinees. These data indicate an increase of 13.6 pounds in the mean weights of white examinees, and 12.9 pounds in those of Negro examinees, within the 20-year span. For both white and Negro examinees most of the increase was in the younger (18–29) age-groups.

White examinees under 25 years of age were on the average about 1.7 pounds heavier, and those 25 years of age and over were about 2.8 pounds heavier, than the Negro examinees of the same age-groups.

For white examinees, the standard deviations of weight were between 21 and 26 pounds, and their coefficients variation between 15 and 17%. For Negro examinees, the standard deviations were between 18 and 24 pounds, and their coefficients of variation between 12 and 15%. The white examinees thus show greater variability than the Negro examinees

with respect to weight, whether measured on an absolute (standard deviation) or on a relative (coefficient of variation) basis.

TABLE 5

Mean heights and weights of registrants examined for military service; standard deviations of these means and their respective coefficients of variation; also modes of weight, by race (January 1943 through January 1944) *

AGE AND RACE	HEIGHT			WEIGHT			
	Inches		C. V.	Pounds		C. V.	Modes
	Means	S. D.	(%)	Means	S. D.	(%)	(Pounds)
WHITE							
18–19	68.06	2.61	3.83	143.70	21.10	14.68	135.90
20–24	68.19	2.60	3.81	149.30	22.35	14.97	140.59
25–29	68.09	2.63	3.86	154.80	24.75	15.99	145.66
30–34	67.83	2.66	3.92	156.70	25.75	16.43	147.57
35–37	67.59	2.64	3.91	157.25	26.05	16.57	148.73
Total (18–37)	68.02	2.61	3.84	150.70	24.00	15.93	141.21
Total—Weighted by 1943-1944 U. S. White Male Population, Ages (18–37)	67.98	2.65	3.90	152.91	24.68	16.14	143.65
NEGRO							
18–19	67.64	2.57	3.80	141.85	17.45	12.30	137.84
20–24	67.91	2.65	3.90	147.85	18.40	12.45	143.26
25–29	67.90	2.64	3.89	151.95	20.80	13.69	145.47
30–34	67.70	2.66	3.93	153.70	22.70	14.77	145.36
35–37	67.51	2.70	4.00	154.70	23.85	15.42	145.74
Total (18–37)	67.76	2.66	3.93	149.40	20.80	13.92	142.56
Total—Weighted by 1943-1944 U. S. Nego Male Population, Ages (18–37)	67.78	2.66	3.92	150.37	21.26	14.14	143.40

* See footnotes to table 1-3; also "Appendix: Technical Notes," with respect to the computation of the "weighted values," and the "modes." S. D. = Standard Deviation; C. V. = Coefficient of Variation.

The most frequent (modal) weights are also presented in table 5 (last column), by age and race. These modal values differ greatly from the mean values caused by the skewed distributions of weight.

HEIGHT AND WEIGHT OF U. S. MALE POPULATION, AGE (18-37)

The mean heights of the examinees as a whole were 68.02 and 67.76 inches for the white and Negro groups, respectively. Their mean weights were 150.7 and 149.4 pounds (table 4).

In addition to these mean heights and weights and other height and weight values, corresponding values marked "weighted" are presented in the table for the whole age-range, by race. It was done because the examined registrants were preponderantly a young population when

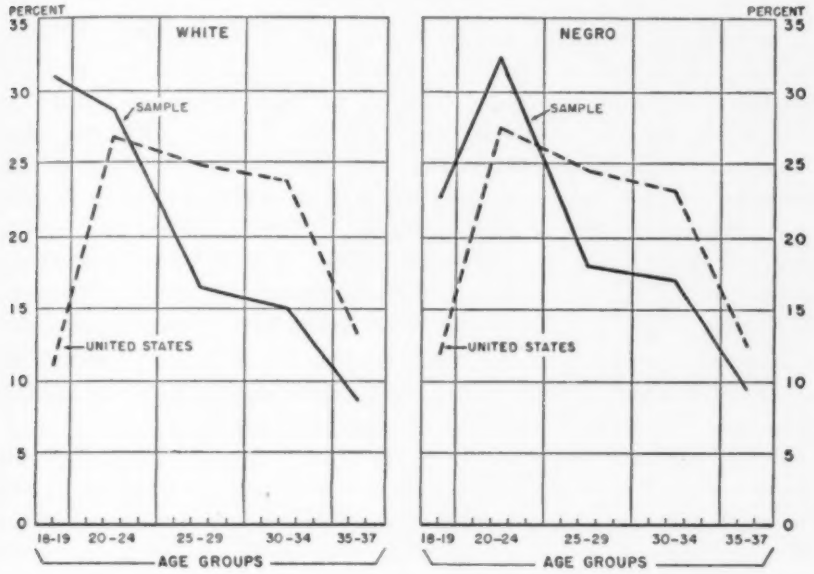

FIG. 1. AGE DISTRIBUTIONS OF SAMPLE AND UNITED STATES POPULATIONS. AGES 18 THROUGH 37, BY RACE, 1943.

compared with U. S. male population within the same age-range, as may be observed from figure 1. The weighted values were computed by applying the age specific height and weight data of the examinees (table 4) to the distribution of the U. S. male population within the (18–37) age-range, by race. (See: "Appendix: Technical Notes," par. 4.)

These "weighted" values obviously reflect more closely the height and weight of U. S. male population within the (18–37) age-range, than the "unweighted" values given in the table for the examinees as a whole.

The differences between the "weighted" and "unweighted" values are primarily with respect to weight.

Based on these data, the following "weighted" mean heights and weights were computed:

a. White males (18–37): Mean height—67.98 inches; mean weight—152.9 pounds.

b. Negro males (18–37): Mean height—67.78 inches; mean weight—150.4 pounds.[1]

DIFFERENTIAL VALUES

Height and weight values by region, size of community, and occupational group are presented in table 6. For some groups the mean heights and weights are above those of the total examined group; for others, they are below. But direct comparison of these differential mean values with total mean values may prove misleading since height and, especially, weight vary with age. Some of the differences in such comparisons might be due to age differences. To eliminate for comparative purposes the effect of age, "expected" mean values of height and weight were computed for each differential group, by race, as given in the table. These "expected" values indicate what would be the mean heights and weights of the particular differential group, if it had the age specific mean heights and weights of the total examined group. (For method of computation, see: "Appendix: Technical Notes," par. 5.)

The importance of comparing the mean values of the differential group with its "expected" mean values, instead of comparing them with the mean values of the total examined group, may be illustrated by the following, though extreme, examples. The mean weight of the white group of proprietors, managers, and officials, for instance, was 159.9 pounds, against a mean weight of 150.7 pounds for the total examined group. By contrasting these mean weights, the particular occupational group would be judged as being about 9 pounds heavier than the total examined group. Actually, the weight of this occupational group is expected to be greater since it is an older age-group—its mean age was 30.5 years as compared with 25.3 years for the total examined group (table 6). When the actual mean is compared with the "expected" mean, this occupational group shows a difference of about 5 pounds

[1] In addition to this analysis by age and race, weight-height relationships were established by age and race, and standard weight-height tables were derived (Karpinos, '58).

(159.9 vs. 155.0 pounds)—one-half in magnitude of what it would be indicated by the former comparison. Another example, the white group of "no occupation" was on the average about four pounds lighter than the total examined group (146.8 vs. 150.7 pounds). This was all due to age differentials. Actually, its mean weight was slightly over its "expected" mean value (146.8 vs. 146.7 pounds).

Differential evaluation should, therefore, be made by contrasting the "actual" wtih the "expected" values, eliminating thus in such comparisons the influence of age-factors. It is also well to remember in connection with such appraisals that the factors responsible for such differences are interrelated. For instance, Northeast has greater concentration of larger cities than, say, South Central, which undoubtedly affects also its occupational distribution.

All height and weight values presented in table 6 have been adjusted for disproportionality, as explained above.

HEIGHT AND WEIGHT BY GEOGRAPHIC REGION

Height and weight values are presented in table 6 by the following geographic divisions: Northeast, Southeast, South Central, North Central, and West, by race. The states included in each of these regions are specified in footnote 2 to the table.

Height. In relation to mean height, the regions arrange themselves in the following ascending order:

a. White: Northeast (67.44 inches)—below its "expected" mean; North Central (68.15 inches), Southeast (68.21 inches), South Central (68.50 inches), and West (68.69 inches)—above their "expected" means.

b. Negro: Northeast (67.28 inches) and Southeast (67.71 inches)—below their "expected" means; North Central (67.74 inches)—the same as its "expected" mean; South Central (68.16 inches) and West (68.34 inches)—above their "expected" means.

These height data seem to indicate about the same regional pattern for both white and Negro examinees, with the Northeast region showing the lowest stature and the West the highest. For both white and Negro groups, the differences in height of these two extreme regions is somewhat over one inch. The data further suggest that where the white examinees were taller, the Negro examinees were also taller. The somewhat lower height noted above for the Negro examinees as a whole, when

TABLE 6

Heights and weights of registrants examined for military service, differentiated by: A. region, B. size of community, and C. occupation, separately for white and Negro

(January 1943 through January 1944)[1]

DIFFERENTIAL CLASS	MEAN AGE (Years)	HEIGHT (INCHES) Actual Means	S. D.	C. V. (%)	Expected Means [2]	WEIGHT (POUNDS) Actual Means	S. D.	C. V. (%)	Expected Means [2]
WHITE									
A. Region [3]									
Northeast	25.6	67.44	2.67	3.96	68.01	152.32	24.61	16.16	150.98
Southeast	25.0	68.21	2.51	3.67	68.02	147.30	23.15	15.73	150.44
South Central	24.8	68.50	2.70	3.95	68.03	147.06	23.83	16.21	150.20
North Central	25.3	68.15	2.54	3.73	68.02	152.04	24.10	15.86	150.72
West	25.1	68.69	2.70	3.93	68.02	151.06	22.93	15.19	150.54
B. Size of Community									
500,000 and over	26.2	67.63	2.69	3.97	68.01	153.30	24.94	16.28	151.53
100,000–499,999	25.8	68.05	2.69	3.95	68.00	151.28	24.60	16.27	150.29
10,000–99,999	25.4	68.07	2.63	3.87	68.01	151.28	24.37	16.12	150.80
2,500–9,999	24.9	68.19	2.58	3.79	68.02	150.07	23.75	15.83	150.34
Under 2,500	24.2	68.19	2.57	3.76	68.04	148.03	22.48	15.19	149.79
C. Occupation									
Professional	28.0	68.39	2.67	3.90	67.97	155.71	25.51	16.39	153.19
Proprietors, managers and officials	30.5	68.10	2.63	3.87	67.89	159.90	27.05	16.93	154.98
Clerks and kindred workers	26.2	68.11	2.62	3.85	68.00	151.61	24.82	16.38	151.56
Farmers and farm laborers	23.0	68.13	2.62	3.85	68.07	143.94	20.41	14.19	148.66
Skilled workers and foremen	26.7	68.10	2.62	3.84	67.99	153.98	24.71	16.06	152.06
Semiskilled workers	25.1	67.93	2.61	3.84	68.04	151.23	23.79	15.74	150.80
Unskilled workers	25.1	67.62	2.67	3.94	68.02	148.03	23.01	15.56	150.48
No occupation	21.4	68.28	2.69	3.93	68.06	146.82	22.49	15.33	146.71
D. Total Examined	25.3	68.02	2.61	3.84	68.02	150.70	24.00	15.93	150.70
NEGRO									

D. Total Examined	25.3	68.02	2.61	3.84	68.02	150.70	24.00	15.93	150.70

NEGRO

A. Region [2]									
Northeast	26.7	67.28	2.70	4.02	67.75	150.19	21.73	14.48	149.65
Southeast	25.6	67.71	2.65	3.91	67.77	148.94	20.09	13.49	148.98
South Central	26.6	68.16	2.62	3.84	67.75	148.81	20.70	13.91	149.58
North Central	27.0	67.74	2.61	3.85	67.74	150.79	22.56	14.97	149.87
West	27.0	68.34	2.59	3.79	67.75	151.97	24.22	15.94	149.94
B. Size of Community									
500,000 and over	27.2	67.46	2.65	3.93	67.75	150.13	22.13	14.75	150.08
100,000–499,999	27.0	67.72	2.66	3.93	67.76	149.48	21.78	14.58	149.89
10,000–99,999	26.4	67.78	2.65	3.90	67.77	149.64	21.04	14.07	149.54
2,500–9,999	25.6	67.95	2.63	3.87	67.77	149.24	20.57	13.79	148.90
Under 2,500	25.0	67.92	2.65	3.90	67.77	148.65	19.24	12.95	148.43
C. Occupation									
Professional	29.0	67.80	2.85	4.20	67.75	154.40	26.77	17.35	151.41
Proprietors, managers and officials	30.5	67.70	2.62	3.88	67.69	158.59	29.04	18.32	152.12
Clerks and kindred workers	25.9	67.43	2.67	3.96	67.76	146.69	22.03	15.03	149.02
Farmers and farm laborers	24.4	67.91	2.64	3.89	67.77	146.99	18.45	12.56	148.02
Skilled workers and foremen	27.4	67.87	2.64	3.88	67.77	151.85	21.70	14.29	150.30
Semiskilled workers	26.7	67.80	2.64	3.89	67.77	151.18	21.77	14.41	149.70
Unskilled workers	26.6	67.73	2.64	3.91	67.77	149.79	20.79	13.89	149.67
No occupation	25.0	67.58	2.70	3.99	67.75	145.79	20.20	13.87	148.16
D. Total Examined	26.1	67.76	2.66	3.93	67.76	149.40	20.80	13.92	149.40

[1] See footnotes to table 5. S. D. = Standard Deviation; C. V. = Coefficient of Variation.

[2] States within each geographic region are as follows: *Northeast*—Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont; *Southeast*—Alabama, District of Columbia, Florida, Georgia, Kentucky, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia,; *South Central*—Arkansas, Louisiana, New Mexico, Oklahoma, Texas; *North Central*—Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, Wyoming; *West*—Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, and Washington.

[3] See "Appendix: Technical Notes" for the computation of the "expected" means of height and weight.

compared with the height of white examinees, may be also noted when appraising their mean heights on a region by region basis.

Weight. In relation to mean weight, the regions array themselves in the following ascending order:

a. White: South Central (147.1 pounds) and Southeast (147.3 pounds)—below their "expected" means; West (151.1 pounds), North Central (152.0 pounds), and Northeast (152.3 pounds)—above their "expected" means.

b. Negro: South Central (148.8 pounds) and Southeast (148.9 pounds)— below their "expected" means; Northeast (150.2 pounds), North Central (150.8 pounds), and West (152.0 pounds)—above their "expected" means.

Both Southern white and Negro examinees seemed to be lighter in weight than those of the North and West. Within the Southern regions and the West, the Negroes seemed to be heavier than the white, while the opposite is true when a parallel comparison is made for the North, where the white appeared heavier than the Negroes.

The regional difference between the maximum and minimum mean weights were about 5 pounds for white examinees, and about three pounds for Negro examinees.

HEIGHT AND WEIGHT BY SIZE OF COMMUNITY

Differentiation by size of community (table 6) was made on the basis of the examinee's place of residence and its classification by size in the 1940 Census.

Height. The mean height seems to increase as one proceeds from the largest to the smallest communities. This is true of white and, to a lesser extent, of Negro examinees.

White examinees coming from cities over 500,000 inhabitants had a mean height about 0.4 inch below their "expected" mean height. Those from cities between 10,000 and 500,000 inhabitants approximated their "expected" mean heights, whereas white examinees from communities of less than 10,000 inhabitants had mean heights about 0.2 inch above their "expected" mean heights.

Negroes coming from cities over 100,000 inhabitants (the two largest city-groups) had mean heights below their "expected" mean heights. The difference is especially noticeable among Negroes from cities over

500,000 inhabitants; their mean height was about 0.3 inch below their "expected" mean height. As in the case of white, Negroes from the smaller communities (under 10,000 inhabitants) were above their "expected" mean height.

Weight. Weight seems to follow the opposite trend from that of height, namely it seems to decrease as one proceeds from the largest to the smallest communities. The decrease is especially noticeable in case of white examinees.

White examinees from the largest cities (500,000 and over) appeared to be by about 1.8 pounds heavier, when comparing their actual and "expected" mean weights (153.3 vs. 151.5 pounds). This holds true also for the next two city-groups: 100,000–499,999 and 10,000–99,999; their mean weights were above their "expected" mean weights, by one pound and one-half pound, respectively, (151.3 and 151.3 vs. 150.3 and 150.8 pounds). White examinees from the small communities (under 2500) were on the average about 1.8 pounds lighter than their "expected" weight (148.0 vs. 149.8 pounds). The last-mentioned groups of examinees consisted to a great extent of a farm population whose mean weight was far below their "expected" weight, as shown later in appraising weight by occupation. Examinees from the largest cities were on the average about four pounds heavier than those from the smallest communities.

No appreciable differences were found when similar comparisons by size of community were made for Negroes.

HEIGHT AND WEIGHT BY OCCUPATION

The examinee's occupation was coded in terms of the major occupational groups—a two-digit code adapted from the Classification Index of the Bureau of the Census, 1940. In the tabulations, however, the data were condensed into the well-known socio-economic groupings as given in table 6.

Height. Considerable variation in height was found among the various occupational groups, primarily among white examinees.

The following occupational groups of white examinees showed mean heights above their "expected" heights: professional persons; proprietors, managers and officials, and individuals of "no occupation." The last group consisted primarily of young people, as evidenced by their mean age (21.4 years). The mean heights of professional persons was 0.4

inches above their "expected" mean height, and the mean heights of the other mentioned occupational groups were 0.2 inches above their "expected" mean heights. The unskilled white workers, on the other hand, seemed to be relatively lower in stature; their actual mean height was about 0.4 inches below their "expected" mean height.

Among Negroes, no material variation in height was found by occupation, except for the clerks and kindred workers, and individuals of "no occupation." These two occupational groups had average heights of 0.3 and 0.2 inches below their "expected" mean heights.

Weight. Pronounced occupational differences were found in regard to weight. Among white examinees, proprietors, managers and officials, professional persons, and skilled laborers were on the average the heaviest. The mean weights of these occupational groups exceeded their respective "expected" mean weights by 4.9, 2.5, and 1.9 pounds, in order named. The average weights of white unskilled workers, and those of white farmers and farm laborers were below their "expected" weights: the mean weight of white unskilled workers was found as 2.5 pounds below their "expected" mean weights, and the mean weight of the white farmers and farm laborers as 4.7 pounds below their "expected" mean weight.

It should be mentioned with respect to the farmers and farm laborers that during this period the Selective Training and Service Act of 1940 was amended to provide for the deferment of registrants found to be "necessary and regularly engaged in an agricultural occupation or endeavor essential to the war effort." This well-known Tydings Amendment might have resulted in the exclusion of the higher economic groups within the farm population. Because of this selection, it is questionable whether the presented height and weight data for the farm and farm laborers could be taken as representative of that particular group.

Among the Negro examinees, proprietors, managers and officials, professional persons, skilled workers, and semi-skilled workers were on the average heavier than the total group. The mean weights of these groups exceeded their "expected" mean weights by 6.5, 3.0, 1.6, and 1.5 pounds, respectively. The other Negro groups (except the unskilled workers), namely farmers and farm laborers, clerks and kindred workers, and individuals with "no occupation" were on the average below their "expected" mean weights. Their mean weights were less than their "expected" mean weight by 1.0, 2.2, and 2.4 pounds, respectively. The mean weight of the unskilled Negro workers was practically the same as their "expected" mean weight.

COMPARISON WITH WORLD WAR I AND OTHER DATA

Overall Comparison: World Wars I and II. According to Davenport and Love ('21), the mean stature of the first million recruits of World War I was 67.49 inches, and their mean weight was 141.54 pounds (table 7). Like those of World War II, these measurements were taken with the recruits stripped.

TABLE 7

Comparison of height and weight of army inductees, World Wars II and I, by region

GEOGRAPHIC REGION [1]	HEIGHT (INCHES)			WEIGHT (POUNDS)		
	WW II	WW I [2]	Gain	WW II	WW I [2]	Gain
Total	68.07	67.49	0.58	150.45	141.54	8.91
Northeast	67.55	66.74	0.81	152.04	139.37	12.67
Southeast	68.14	67.92	0.22	147.57	140.81	6.76
South Central	68.58	68.19	0.39	147.54	141.60	5.94
North Central	68.20	67.63	0.57	151.63	142.77	8.86
West	68.74	67.85	0.89	151.19	144.67	6.52

[1] See footnote 2, table 6.

[2] Derived from tables 13 and 30, Davenport and Love ('21).

The term "recruit," as was employed in World War I, referred to individuals examined at military camps after they had been screened out by the local boards. During World War I, local board screening was of primary nature and was not restricted to eliminating men with manifestly disqualifying defects as was the case during the period to which our data of World War II relate. It is, therefore, appropriate to compare the height and weight of World War I recruits with those of World War II inductees, as done in table 7.

A direct comparison of these height and weight data indicate that the World War II inductees were on the average 0.6 inch taller (68.07–67.49) and 8.9 pounds heavier (150.45–141.54) than the World War I recruits. Actually, however, the differences in these measurements are larger than those indicated by this comparison, since the inductees of World War II were on the average younger than the recruits of World War I. When due allowance is made for the age differences of the inductees of the two considered periods, the age-adjusted height and weight values would indicate that within the same age-range the inductees of World War II were about two-thirds of an inch taller and about 10.7

pounds heavier than those of World War I. (The adjustment for age was made by applying the present age specific height and weight values to the age distribution of the World War I recruits as given in Davenport and Love, '21, table 2. See: "Appendix: Technical Notes," par. 5.)

World War II data indicate less variability with respect to height—the standard deviation for height were 2.62 and 2.71 inches for World War I and II, respectively, but greater variability with respect to weight—the respective standard deviations for weight were 22.1 and 17.4 pounds. The height and weight distribution of World Wars I and II are graphically depicted in figure 2. The distribution of World War II examinees by weight shows a wider scatter toward higher weights than that of World War I.

Regional Comparison: World Wars I and II. Davenport and Love ('21) noted geographic (state) differences in height and weight data of World War I. Since the present data were not available by state, the state data of World War I were combined for comparison into the geographic regions used for World War II data. The World War I data by regions are presented in table 7, alongside with the corresponding World War II data for inductees. The gains in height and weight between World Wars I and II are also shown in table 7, by region.

In discussing the geographic differences in height in World War I, Davenport and Love ('21) attributed these in part to regional differences in the influx, shortly before World War I, of immigrants from southeastern Europe, namely, of men of relatively low stature. For instance, they offered this immigation factor, in particular, and the high proportion of certain foreign-born men in the population, in general, as an explanation for the relatively lower stature of recruits from the Northeast region. These factors appeared to be still operative to a certain extent in World War II.

As may be seen from table 8, the proportions of foreign born white males of military age were markedly decreased during the periods close to World Wars I and II. Between 1920 and 1940, the precent of foreign born white males declined from 18.5 to 4.4, within the (20–34) military age-range. However, these proportions still remained relatively high in World War II in Northeast, West, and North Central regions, though in absolute terms the largest decrease in the proportions of foreign born occurred within these regions. It is within these regions that the largest gains in height occurred between World Wars I and II.

The gains in height by regions were as follows in ascending order:

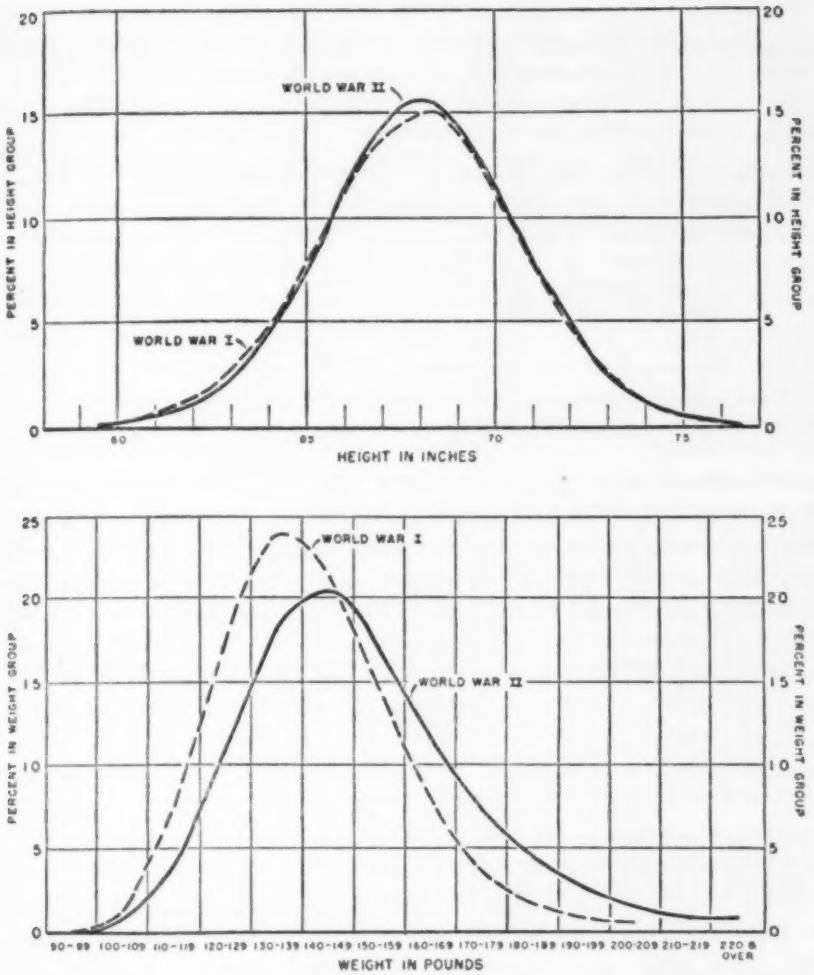
WORLD WAR II
WORLD WAR I
PERCENT IN HEIGHT GROUP
HEIGHT IN INCHES
WORLD WAR I
WORLD WAR II
PERCENT IN WEIGHT GROUP
90-99 100-109 110-119 120-129 130-139 140-149 150-159 160-169 170-179 180-189 190-199 200-209 210-219 220 & OVER
WEIGHT IN POUNDS

FIG. 2. PERCENT DISTRIBUTION OF HEIGHTS AND WEIGHTS. ARMY INDUCTEES, WORLD WAR II, COMPARED WITH RECRUITS, WORLD WAR I.

Southeast—0.22; South Central—0.39; North Central—0.57; Northeast —0.81, and West—0.89 inches (table 7). This suggests that the gains in height may at least in part be ascribed to an increase in the homogeneity of the population-composition between World Wars I and II.

The gains in weight by region were as follows, in ascending order: South Central—5.9; West—6.5; Southeast—6.8; North Central—8.9,

TABLE 8

Percent of foreign born white males, ages 20 through 34, as of total white males of the same ages, by geographic region (1910-1950) *

GEOGRAPHIC REGION	PERCENT FOREIGN BORN				
	1910	1920	1930	1940	1950
Total	24.2	18.5	11.4	4.4	2.5
Northeast	27.7	24.5	22.0	17.8	14.0
Southeast	3.1	2.7	2.1	1.7	1.7
South Central	5.9	6.3	4.8	2.9	2.9
North Central	17.8	15.2	12.6	9.2	6.7
West	24.5	20.8	17.8	12.3	8.9

* Computed from various Census reports. See footnote to table 6 for the states within each geographic region.

and Northeast—12.7 pounds. Part of these gains in weight between World Wars I and II may be attributed to increasing height. Mostly, however, it is apparently due to improved nutrition—both quantitatively and qualitatively. Further investigations are required to explain the wide differences found in the gains of weight by region.

Other Comparisons. Further comparable—though fragmentary—

TABLE 9

Comparative height and weight data *

INDUCTEES OR RECRUITS	HEIGHT (INCHES)		WEIGHT (POUNDS)	
	Mean	S. D.	Mean	S. D.
U. S. Army Inductees, World War II:				
Age (18–19)	68.12	2.56	144.56	19.77
Age (20–24)	68.20	2.58	149.51	21.00
English Recruits (1939), Age (20–21)	67.50	2.62	135.70	16.54
Royal Air Force Personnel (1948):				
Age (18–19)	67.52	2.52	132.15	15.26
Age (20–25)	68.17	2.54	138.58	15.01
English Army Intake (1951):				
Age (18–19)	67.77	2.62	137.37	16.68
Age (20–24)	68.16	2.59	143.09	17.20

* Sources: English Recruits (1939): Martin ('49); Royal Air Force Personnel: Morant ('49), Tables I and II (All Stations), at the beginning of training; English Army Intake (1951): Rosenbaum ('54), Tables 1 and 5.

height and weight data are presented in table 9. The data are for English recruits for the following periods: 1939, 1948, and 1951.

The U. S. inductees of World War II appear on the average somewhat taller and much heavier than the English recruits either of 1939 or 1948, and even of 1951. The English instructions for taking the height and weight measurements require that men wear trousers and socks. Corrections of one-quarter inch for height and from two to three pounds for weight are usually made in comparing these measurements with those taken in the nude (Rosenbaum, '54). Hence, U. S. inductees seemed to be on the average about one-half inch taller and 10–14 pounds heavier than the English recruits.

HEIGHT AND WEIGHT OF REGISTRANTS WITH TUBERCULOSIS

Except for registrants who were disqualified for tuberculosis, no attempt was made to relate the height and weight data to any disease or defect. The mean heights of the tuberculous registrants were as follows: White—68.29 inches; Negro—67.90 inches, exceeding the mean heights of all examinees by 0.27, and 0.14 inches, respectively. Analogous differentials were noted by Davenport and Love ('21) for World War I, who reported the average stature of recruits with pulmonary tuberculosis as 0.58 inch above the mean height of all recruits. The mean height of the tuberculous patient of World War II was about the same as that of World War I (68.1 inches—World War I). (See Long and Jablon, '55, p. 82, on the relationship of tuberculosis and constitutional factors.)

With respect to weight, the following averages were found for tuberculous registrants in World War II: white—146.9 pounds; Negro—145.0 pounds. These figures indicate for white and Negro tuberculous registrants mean weights of 3.8 and 4.4 pounds below the mean weights of the examined groups. According to Davenport and Love ('21), the average weight of recruits with tuberculosis in World War I was 11 pounds below the average of all recruits.

In spite of the fact that the tuberculous registrant of today is about four pounds lighter than the average registrant, his mean weight is about five pounds above the mean weight of the recruit of World War I, and about 16 pounds above that of the recruit of World War I with tuberculosis. (The average weight of the World War I recruit with pulmonary tuberculosis was 130.4 pounds.) These data exclude institutionalized cases of tuberculosis.

SUMMARY

1. The findings presented here are based on an analysis of height-weight data abstracted from about half-million physical examination forms (DSS Form 221). These forms were selected at random from about five million forms received at the Surgeon General's Office, Army, on Selective Service registrants processed for military service in World War II during the thirteen-month period—from January 1943 through January 1944. These registrants were within the age limits of 18 through 37, but primarily (about 40%) concentrated in the under 21 age-group.

2. Among both white and Negro examinees, the (20–24) age group —age of maturity—had the highest stature: 68.19 and 67.91 inches, respectively. The mean heights of the (18–37) groups, as a whole, were computed as 68.02 and 67.76 inches, for white and Negro examinees, respectively (table 5).

3. With respect to weight, their means ranged from 143.7 to 157.3 pounds for white examinees, and from 141.8 to 154.7 pounds for Negro examinees, within the 20-year period: from (18–19) through (35–37) age-groups. The mean weights for these examinees, as a whole, were computed as 150.7 and 149.4 pounds, for white and Negro examinees, respectively (table 5).

4. The Negro examinees appeared somewhat shorter and much lighter than the white examinees (table 5).

5. Differences in height and weight were found among examinees from the various geographic regions. Examinees from the West and South Central regions proved to be taller than those of other regions. On the other hand, examinees from Northeast and North Central were the heaviest (table 6).

6. Examinees from the largest cities appeared to be shorter and heavier and those from the smallest communities taller and lighter, than all examinees (table 6).

7. Examinees higher on the socio-economic scale appeared relatively taller and heavier (table 6).

8. Compared with the recruits of Word War I, the inductees of World War II were found about 0.6 inch taller and about 9 pounds heavier (table 7). When adjustments were made for the differences in their age distributions, the inductees of World War II seemed to be on the average two-thirds of an inch taller and by about 10.7 pounds heavier

than the recruits of World War I. The distribution of the examinees of World War II by weight shows a greater scatter towards heavier weights than that of World War I (figure 2).

9. The data indicate marked differences among regions in the gains of height and weight between World Wars I and II. The greatest increase in height occurred in the West and Northeast; the greatest increase in weight took place in Northeast and North Central (table 7).

10. Comparison between U. S. World War II inductees and English recruits indicate that the U. S. inductees of World War II were about one-half inch taller and 10–14 pounds heavier than the English recruits of that period (table 8).

11. Tuberculous registrants were found taller and lighter when compared with all examinees.

APPENDIX: TECHNICAL NOTES

1. *General.* As pointed out in the text, about one-fourth (23.6%) of the qualified registrants were inducted during this period into the Navy. No provision was made to furnish the Surgeon General's Office, Army, with copies of the physical examination forms of the Navy inductees. The qualified group included in this study was hence limited to Army inductees, resulting in a partial coverage of this group.

Since intergroup (inducted vs. qualified) as well as intragroup (age) differences were found with respect to the height and weight values, it became evident that the height and weight values for the total examined group cannot be obtained by directly combining the height and weight data of the disqualified with those of the inducted examinees. Such a procedure would have given undue proportionality to the disqualified group. To correct for this disproportionality, determination had to be made first as to whether the Army inductees could be taken as representative of all inductees with respect to height and weight.

There were some differences in the manner of assigning qualified registrants to the Army or the Navy. For one thing, qualified registrants classified as "limited service" could not be assigned to the Navy. However, a study of the "limited service" inductees showed that the distributions of these inductees by height and weight were essentially the same as those of the other inductees. For another, qualified registrants, excluding "limited service," were further classified as "general service," acceptable for both the Army and the Navy, and

"special assignment" who were acceptable for the Army alone until June, 1943. The latter group of registrants included acceptable illiterates and registrants who met the Army's visual and hearing standards for general service, but not those of the Navy (Surgeon General's Office, '44). Judging from the composition of the "special assignment" group, there was no reason to suppose that the height and weight data of this group could have been materially different from those of the "general service" group. Furthermore, the number of registrants in the "special assignment" group was relatively small, in addition to the fact that the restriction with respect to their assignment to the Navy was effective only for the first five months of the thirteen-month period under consideration.

However, there was a third difference directly related to height and, hence, to weight. While the acceptable height-range for Army inductees was between 60 and 78 inches, that of the Navy was restricted to 62 through 76 inches. Therefore, the adjustments were made in the cross-tabulations of the Army inductees by height and weight within the height-range of 62 to 76 inches.

2. *Adjustment Factors.* In addition to the copies of the physical examination reports (DSS Form 221) forwarded to the Surgeon General's Office, Army, each induction station was required to submit a monthly report ("Monthly Report of Examinations at Joint Army and Navy Induction Station,") relating to the general results of these examinations. This report showed for each Army Area and State, by race: the number examined; number disqualified, distributed by the principle disqualifying cause, and number of inductees, by type of qualification (general service, special assignment, and limited service), and department of assignment: Army or Navy (Surgeon General's, '44).

On the basis of the data obtained from these monthly reports, the ratios of qualified to disqualified registrants were established, by race. The adjustment factors for the qualified groups were thus determined as 1.32, and 1.11 for white and Negro inductees, respectively.

Those adjustment factors were applied to each age-group within the particular qualified group, since age was not a selective factor in the assignment of the Army or the Navy. Each cross-tabulation of the Army inductees by height and weight was adjusted within the height-range of 62 to 76 inches. Each adjusted cross-tabulation of the qualified registrants was then combined with the corresponding cross-tabulation of the disqualified registrants to obtain the proper cross-tabulations for the total examined.

3. *Determination of Modes.* The modes were computed by utilizing four moments (Croxton and Cowden, '55, p. 190, footnote 5).

4. *Height and Weight Values for U. S. Male Population (18–37).*

a. General. Since height and, particularly, weight differ with age, and since the distribution by age of the U. S. Male population within the age range of (18–37) is much different from that of the total examined group, as may be observed from figure 1, the various values (means and standard deviations) for total U. S. male populations, aged 18–37, had to be obtained by weighting the specific age values of the examined group by the age distribution of U. S. male population, by race. The procedures applied for computing these required "weighted" values are explained in *b*, below.

b. Weighted Means and Weighted Standard Deviations. Let $\bar{X}_i$ and $\bar{Y}_i$ represent the respective means of height and weight of any age-interval within any examined group, while $\bar{X}$ and $\bar{Y}$ the corresponding mean values of the combined group.

Obviously, $$\bar{X} = \sum w_i \bar{X}_i \qquad (1),$$

where w_i is the proportion of any age group within the total group ($\sum w_i = 1.000$). For U. S. male population (18–37), w_i represents its proportional age distribution within this age range, which was determined as follows on the basis of supplied Census data:

White: Under 20—.1070; 20–24—.2699; 25–29—.2490;
30–34—.2389; 35–37—.1352 ($\sum w_i = 1.0000$),

Negro: Under 20—.1169; 20–24—.2806; 25–29—.2443;
30–34—.2337; 35–37—.1245 ($\sum w_i = 1.0000$).

The corresponding standard deviations were derived on the basis of the following relationship of the variance:

$$V(X) = \sum w_i[V(X_i) + \bar{X}_i^2] - \bar{X}^2 \qquad (i = 1, \cdots, k) \qquad (2),$$

where $V(X)$ represents the variance of the total U. S. male group; $V(X_i)$—the variance of the particular age group; $\bar{X}_i$ and $\bar{X}$, as in (1), above. The same holds, of course, for Y. (See Kenney, '47, corollary 1, p. 101.)

5. *"Expected" Values.* The "expected" values given in table 6 were computed by what is known as the "indirect" method of standardization. Briefly stated, this method is used in comparing values of two or more groups whenever these groups differ with respect to some variables, say age, but the specific values by this variable are unknown. In our case, the average height and weight are known for each differential group (table 5), as a whole, but not by age. A direct comparison of the mean height and weight of any differential group with those of all examinees would hardly be justified since these groups differ considerably in age, while height and, especially, weight are a function of age. The indirect method of standardization is used in order to eliminate the effects produced by age differences. It was accomplished here by multiplying the age specific height and weight values of the total examined group by the age distribution of the particular differential group. (Age distribution of each differential group was available.) The obtained values are the "expected" values. The differences between the actual values of differential group and its "expected" values reflect actual differences, not affected by age. (See: Stouffer, '51, for a detailed discussion in regard to this method of standardization.)

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SOME INTERRELATIONS BETWEEN SOMATIC, ROENTGENOGRAPHIC AND DENSITOMETRIC CRITERIA OF FATNESS[1]

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AN individual's leanness-fatness may be estimated on the basis of several procedures, varying in the complexity of manipulations and underlying assumptions (Keys and Brožek, '53). Here we have considered three procedures: caliper measurements of skinfold thickness, measurements on soft-tissue roentgenograms of the extremities, and body density determinations.

Interrelations between these approaches were examined from three points of view:

1) Using body density as a criterion of the fat content of the body as a whole, correlations with the thickness of subcutaneous adipose tissue were computed. They represent a measure of the *validity* of linear somatic and roentgenographic measurements as indicators of total body fat. In addition, the usefulness of employing absolute or relative measures of the layer of subcutaneous adipose tissue, taking into account body size, was examined.

2) Correlations between skinfolds and roentgenographic widths indicate the *reliability* of the two procedures which aim to measure the same thing, i.e. the thickness of the *panniculus adiposus*.

3) In addition to the assessment of the degree of association among

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the variables under study, prediction equations were calculated in order to make possible comparisons of data obtained by the three procedures and, in particular, to provide means for converting the roentgenographic values into densitometric estimates of total body fat. Such equations had been provided for skinfolds (Brožek, '54; Pascale *et al.*, '56), even though additional work in this direction is necessary in order to take into account more adequately the variables of sex and age as well as the advances in the techniques of measurement and their standardization (Committee, '56).

This presentation is focused on the relations between density, considered as indicator of total fat content of the body, and the roentgenogrammetrically determined thicknesses of subcutaneous fat. Data were provided for the empirical appraisal of the value of absolute thicknesses vs. thicknesses related to various criteria of body size.

METHODS AND PROCEDURES

In determining body density, defined as the ratio of mass and volume, body volume was obtained by underwater weighing. The water temperature was kept at $36 \pm 0.5°C$. The air remaining in the lungs and respiratory passages at the end of maximal exhalation (i.e. at a moment when the weight under water was read) was determined for each individual by the nitrogen-dilution technique and the value was subtracted from the gross volume of the body (Brožek, *et al.*, '49).

Skinfold thickness was measured at the back of the right upper arm, over the triceps. The level at which the measurement was made was defined as halfway between olecranon and acromion, and was marked with a dermatographic pencil. The level of the upper arm, one-third of the distance up from the olecranon, was also marked for positioning the upper arm for soft-tissue roentgenograms (Site No. 3, see below). In making the skinfold measurements the caliper was applied with a pressure of $10\,gm/mm^2$ of the circular contact surface ($25\,mm^2$).

Soft-tissue roentogenograms were taken at a tube-to-film distance of 72 inches. The following sites were used, for exploratory purposes, on the right extremities:

1) Upper arm, in anteroposterior (A-P) projection, at the level of deltoid insertion.

2) Upper arm, in medio-lateral projection (M-L), half-way between olecranon and acromion, at a level at which the skinfold thickness was

measured. The dorsal roentgenographic fat measurement corresponds to one-half of the uncompressed skinfold.

3) Upper arm, in A-P projection, one-third of the distance between olecranon and acromion.

4) Forearm, in a position of supination (palm of the hand facing upwards), A-P projection, at the level of maximal width.

5) Thigh, one-third of the distance between the lower border of the patella and the anterior superior iliac spine, A-P projection. Because of the size of the casette used, only the medial thickness of subcutaneous layer was considered.

6) Calf, in A-P projection, at the level of maximal width.

The measurements of the thickness of the adipose tissue layer, muscle and bone were made as follows:

At the point of deltoid insertion (Site No. 1) the thickness of the layer of skin and subcutaneus tissue was measured along the line vertical to the skin (*cf.* Garn, '54, who used on P-A projection).

At sites No. 4 and 5 (forearm and calf) the measurements of adipose layer, bone and muscle or bone plus muscle (in Site No. 4) were taken perpendicularly to the long axis of the limbs (line connecting the middle points of the upper and lower edges of the section of a limb), at the level of the widest diameter.

At Sites No. 2, 3, and 5 (upper arm and thigh) the measurements of soft tissues were made along the line perpendicular to the long axis of the limb, same as in Sites No. 4 and 6. Bone width was measured perpendicularly to the long axis of the bone.

Fig. 1 shows three examples of the method of measurement. For purposes of comparison with data reported in the literature, the dorsal fat layer in Site No. 2 (mid-upper arm) was measured also vertically to the skin.

SUBJECTS

The subjects were drawn from a group of middle-aged business and professional men participating in a longitudinal study of aging of the cardio-vascular system. The need for selection resulted from the fact that the densities were determined in 1951 while the soft-tissue X-rays were taken in 1955. Skinfold measurements were made on both occasions. The present sample consists of men whose 1955 weight did not differ by more than $\pm 2\%$ from the 1951 weight. In one-half of the

men the weight changes were within ± 1% while in the other half the body weight varied by more than ± 1% but did not exceed ± 2%.

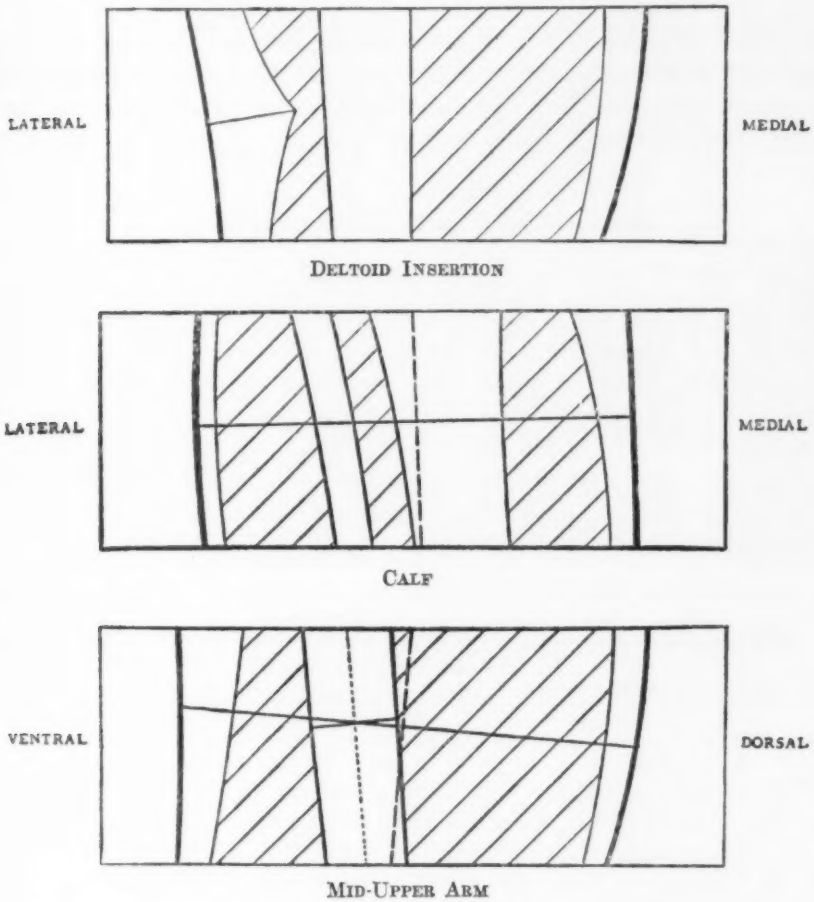

FIG. 1. TECHNIQUE OF MEASURING SOFT-TISSUE ROENTGENOGRAMS. LIMB AXES ARE INDICATED BY LONG DASHES, BONE AXIS BY SHORT DASHES. THE LINES ALONG WHICH THE MEASUREMENTS WERE MADE ARE SOLID.

The general characteristic of the sample, referring to the year 1955, are given in table 1. The age range was quite narrow while the variability in relative body weight, obtained by referring the actual weight to the tabular age-height-weight standards, was very close to that found in the population from which the subsample was drawn (Brožek and

TABLE 1

Means and standard deviations of the general characteristics of the sample ($N = 52$)

	MEAN	SD
Age, years	57.1	2.7
Height, cm.	175.9	6.7
Weight, kg.	80.2	10.4
Relative body weight, %	104.3	12.2

Keys, '51, p. 200). The mean actual weight exceeded slightly the reference weight but it should be pointed out that the height-weight tables used (Association, '12) do not go beyond the age of 55 and, consequently, values of relative body weight of adults in the upper age range are only approximate. The fact that the subjects were weighed in light trunks, while the insurance applicants on whom the reference tables are based were weighed in indoor clothing and with shoes on, further stresses the approximate character of the reference values a criterion of "normality" of weight.

TABLE 2

Medians, means and standard deviations of the 3 types of fatness indicators
(Thicknesses are given in mm)

CHARACTERISTIC	MEDIAN	MEAN	*SD*	*N*
Body density	1.0392	1.0401	0.0124	52
Skinfold thickness				
Upper arm, ½ up, dorsal	13.2	13.0	4.1	52
X-ray measurements				
Deltoid insertion	18.0	17.9	3.6	42
Upper arm, ½ up, dorsal	7.8	7.9	2.4	52
Upper arm, ½ up, dorsal & ventral	15.8	16.4	4.8	52
Upper arm, ½ up, medial & lateral	17.9	17.8	4.2	41
Forearm, max. width, medial & lateral	10.9	10.9	3.0	51
Thigh, ½ up, medial	17.4	17.4	4.4	42
Calf, max. width, medial & lateral	11.0	11.4	3.3	47

The medians, means and standard deviation of body density, skinfold thickness and the thicknesses of skin-plus-subcutaneous layer measured on roentgenograms are given in table 2. The distributions were only moderately asymetrical. Body density, converted into total body fat by using the 1953 equation of Keys and Brožek ('53), indicates that on the average 22.6% of body weight may be accounted by body fat. In comparing the average skinfold with data reported in the literature the pressure used (10 gm/mm² in this study) should be taken into account.

INTERRELATIONS BETWEEN MEASUREMENTS

On the average, half of the skinfold is 6.5 mm, corresponding to 82.3% of the roentgenogrammetric value of skin plus subcutaneous layer (table 2), measured at approximately the same place. The difference is due largely to the compression of the skinfold. The caliper pressure is, clearly, a crucial factor. There may be regional and other (sex, age) factors that may modify the degree of effective compression. These problems require further research.

A small amount of the difference between skinfolds and X-ray measurements is contributed by the magnification of the roentgenographic values as a result of the fact that the rays, even at a focal-film distance of 6 feet, are slightly divergent, not parallel, and the median plane of the limbs is separated from the film plane. The average magnified arm measurements were about 102.5% of the "true" value.

The equations relating the three types of measurements of leanness-

TABLE 3

Equations ($Y = a + bX$) interrelating body density, skinfold thickness (upper arm, ½ up, dorsal) and the dorsal width of the subcutaneous layer of upper arm measured on roentgenograms at approximately the same site

Y	*X*	*a*	*b*
Body Density	Skinfold (mid-upper arm, dorsal)	1.0672	—0.0021
Body Density	X-ray width (mid-upper arm, dorsal)	1.0655	—0.0032
Skinfold (mid-upper arm, dorsal)	X-ray width (mid-upper arm, dorsal)	1.55	+1.44
X-ray width (mid-upper arm, dorsal)	Skinfold (mid-upper arm, dorsal)	1.83	+0.47

fatness are given in table 3. In calculating individual values of body density only three decimal figures are significant and the calculated values should be so rounded. Similarly, the predicted figures of subcutaneous fat should be rounded out to the tenth of a millimeter or to the nearest half-millimeter (for skinfolds measured with this precision).

The closeness of the association is indicated by the coefficients of correlation (table 4). It is of interest to note that the thickness of the dorsal skinfold does not show a lower correlation with total body fat than the corresponding roentgenographic measurement, as might perhaps be expected. The coefficient of correlation between the two approaches (somatometric and roentgenogrammetric) to the measurement of subcutaneous fat is similar to the values reported in the literature.

TABLE 4

Coefficients of correlation between body density, dorsal skinfold thickness, and dorsal width of subcutaneous layer of upper arm measured on roentgenograms

X	*Y*	*r*	*N*
Density	Skinfold	—0.68	52
Density	X-ray width	—0.63	52
Skinfold	X-ray width	+0.82	126

Coefficients of correlation between body density and combined—dorsal and ventral, lateral and medial—roentgenographic measurements tend to be usefully higher (table 5, last column) than when single measure-

TABLE 5

Cofficients of correlation between body density and separate versus combined (Dorsal and Ventral, Lateral and Medial) roentgenographic measurements of the thickness of the subcutaneous fat layer (plus skin)

Upper arm, middle	—.63 (D)	—.67 (V)	—.73 (D & V)
Upper arm, ½ up	—.64 (L)	—.62 (M)	—.75 (L & M)
Forearm	—.67 (L)	—.74 (M)	—.76 (L & M)
Calf	—.34 (L)	—.66 (M)	—.58 (L & M)

ments are utilized. The only exception is the calf in which the lateral width is a substantially poorer indicator of total fat than the medial width. Equations for predicting body density from roentgenographic data are given in table 6.

TABLE 6

Equations for predicting body denstiy ($\hat{Y}$) from roentgenographic measurements, X, in mm, in middle aged men ($\hat{Y} = a + bX$)

X	a	b
Deltoid insertion, (Upper arm)	1.0722	—0.0019
Upper arm (midway, dorsal + ventral)	1.0712	—0.0019
Upper arm (lower third, medial + lateral)	1.0781	—0.0022
Forearm (maximum width, medial + lateral)	1.0729	—0.0031
Thigh (lower third, medial)	1.0624	—0.0014
Calf (maximum width, medial + lateral)	1.0645	—0.0023

The data on actual versus size-corrected measurements of roentgenographic widths of subcutaneous adipose tissue (plus skin) are presented in Table 7. The first column refers to the actual, uncorrected measure-

TABLE 7

Coefficients of correlation between body density and absolute (X) or relative measurements of subcutaneous fat (as ratios to stature, L; to the corresponding bone width of the limb, B; and to bone plus muscle width, B + M)

	X	X/L	X/B	X/(B + M)	N
Deltoid insertion, upper arm	—.60	—.66			
Upper arm, middle, dorsal	—.63	—.64	—.64	—.63	52
Upper arm, middle, dorsal and ventral	—.73	—.75	—.76	—.73	52
Upper arm, lower third, medial + lateral	—.75	—.75	—.74	—.68	41
Forearm, max. width, medial + lateral	—.76	—.77		—.79	51
Thigh, lower third, medial	—.51	—.52	—.51		42
Calf, max. width, medial + lateral	—.58	—.59	—.57	—.56	47

ments. Relating the roentgenographic fat measurements to various indicators of "size"—stature, width of the bone measured at a given level of the limbs, or combined width of bone and muscle—does not substantially increase the size of the coefficients of correlation with body density. Only the consideration of body length resulted in consistently higher coefficients. However, even here the magnitude of the differences was negligible.

It should be pointed out that the coefficients of correlation between roentgenographic measurements and density are somewhat reduced because of changes in weight (and fatness) that took place between 1951, when the body densities were determined, and 1955, when the soft tissue roentgenograms were taken. Fortunately, skinfold measurements were made in both years and the magnitude of the difference due to this source of variability may be estimated. The coefficients of correlation with body density were —0.683 using the 1955 skinfolds ($N = 52$), and —0.723 using the 1951 skinfolds ($N = 52$). For the group as a whole ($N = 160$), the r obtained for 1951 values of both density and skinfolds was —0.726.

DISCUSSION

Single sites versus combined measurements

Roentgenographic measurements of subcutaneous fat may serve one of two, diametrically opposed, goals: 1) One may wish to describe the patterns of distribution of subcutaneous fat (*cf.* Garn, '55, p. 537) and to bring out the *regional differences* in fatness by contrasting, *e.g.*, the fat depots on the extremities and those on the trunk, or 2) one may be interested in arriving at the best estimate of *total* fat, i.e. of the "fatness" of the organism rather than the fatness of particular regions (*cf.* Garn, '57).

The latter purpose is served best by combining the separate measurements in the form of multiple regression equation, as has been done for skinfolds (Brožek and Keys, '51). This technique provides means for optimal weighing of the measurements made at different sites and for the elimination of those variables that do not contribute significantly to the precision of the prediction. Neither of these important features is present when the single measurements are simply added (or averaged). In the present series the number of individuals for whom all of the required data were available was considered too small for the task of

combining the single sites in the form of a multivariable prediction equation. This is, clearly, an urgent task for future research.

Effect of size

The problem of absolute (actual) and relative values of subcutaneous adipose tissue as indicators of total body fat is intriguing. It has been a fairly general practice, in adults at least, to use the actual (absolute) measurements as a criterion of leanness-fatness. On theoretical grounds, considerations of body size would appear to be called for. The available evidence, however, is essentially negative.

We have seen (table 5) that relating—in the form of an index—the subcutaneous layer to stature, width of the bone of the extremity, or to the width of bone plus muscle, has only increased negligibly or has even depressed, in the case of bone and bone-plus-muscle used as standards of reference, the correlation with body density.

This is in line with our previous experience with absolute and relative skinfolds. We were unable to demonstrate (Keys and Brožek, '53, p. 262) any gain in the precision of prediction of body density from skinfolds when surface area (based, in its turn, on height and weight) was taken into account as a measure of body size. The correlations between height and the thickness of subcutaneous layer of adults tend to be close to zero whether one uses roentgenographic data (*cf.* Reynolds, '50, p. 69, values for the age level of 15.5 years) or skinfold (Brožek, '56, p. 137).

In this study the sample of adults was of the same sex and highly homogeneous in age. In comparing the relative fatness of the sexes, Reynolds ('49) found useful the fat/bone index. It reflects the fact that females not only tend to have larger absolute breadths of subcutaneous fat (19.7 vs. 9.6 mm at the calf) but their bone breadths are smaller (32.8 vs. 39.5 mm; *cf.* Reynolds and Groote, '49, p. 47). Under these conditions, a relative fat breadth shows the difference in fatness more distinctly than the absolute fat breadths.

Prediction of total body fat

The prediction equations (tables 3 and 6) have primarily a practical value, enabling one to "translate" one set of measurements into another. This applies especially to the relations between skinfolds and roentgenographic values of subcutaneous fat. Predictions of body density are of greater interest inasmuch as they make it possible to estimate the total amount of body fat and thus yield information needed in studies in

which a fat-free weight is sought as a reference point in metabolic and physiological investigations.

The derivation of the equation for calculating body fat (F), as percentage of body weight, from body density (D)

$$F = 100[(4.201/D) - 3.813]$$

has been given elsewhere (Keys and Brožek, '53; Brožek, '54), together with the quantitative assumptions on which the equation is based. Some of these assumptions, such as the density of "cell mass," are being currently replaced by more reliable constants. This will result in a modification of the equation given above. For this reason it is preferable to calculate the correlations between partial indicators of body fat and body density, rather than the total fat estimated from a particular densitometric equation.

Care should be taken not to apply the equations predicting density from measurements of subcutaneous fat too readily to individuals differing in sex or age from the sample for which the basic data were obtained. Subcutaneous fat is only a fraction, be it a large one, of the total body fat. It was noted (Brožek, '55, p. 498) that the same skinfold thickness is associated with a higher total fat content in middle-aged men than in young men. An equation derived for the older men would overestimate the total body fat of young men. The difference is due to the different amounts of internal fat. The sex differences in this regard remain to be examined.

Skinfolds vs. roentgenographic values

The spot at the dorsum of the upper arm at which the skinfold was measured was marked with dermatographic pencil and an attempt was made to place the arm in front of the casette in such a way that the site could be located on the roentgenogram. However, as no lead marker was applied in this series, as has been done by Garn and Gorman ('56), and the arm was not clamped in a rigid position, the location was reproduced only approximately on the roentgenograms.

The coefficient of correlation between the thickness of dorsal skinfold, measured on the upper arm, and the corresponding roentgenographic reading for our subjects was 0.824 ($N = 126$), a value that is similar to those available in the literature. Baker ('55) reported $r = 0.852$ ($N = 83$ young adults), presumably for the same site as was used in our study. Hammond ('55, p. 207) obtained r values of 0.82 for the thigh, 0.83 for biceps, and 0.89 for the triceps in a sample of about

150 boys of unspecified age. In Garn's ('56) sample of 65 young men, $r = 0.88$ for measurements made at the levels of the lowest rib at the midaxillary line. On this site the median caliper value of the skinfold (12.0 mm) was only 65% of the radiographic equivalent (2×9.3 mm $= 18.6$ mm). The compression effect is larger, even though presumably the caliper spring exerted the same pressure as in the present study (*i. e.* 10 gm/mm^2) in which the average skinfold value represented 82.3% of the doubled roentgenogrammetric width.

A check was made as to whether the method of measurement (vertical to skin in Garn's work, vertical to the axis of the limb in the present study) would account for the difference between roentgenographic values and skinfolds. The means and S. D.'s for the dorsal width of adipose tissue at the mid-upper arm were 7.90 ± 2.40 mm for the subsample used for correlations with body density ($N = 52$, table 2) and 7.95 ± 2.57 for the total sample ($N = 126$). The corresponding values obtained for measurements made vertically to the skin were 7.86 ± 2.42 and 7.94 ± 2.55, *i. e.* the means were only negligibly smaller. The coefficients of correlation between skinfolds and X-ray widths were 0.824 (table 4) and 0.825, respectively. Thus, at this particular site, the two methods yield essentially identical values and can not account for the differences between Garn's and our data on skinfolds expressed as percentages of roentgenographic fat thicknesses. The problem of regional and age differences in the compressibility of adipose tissue is under study.

SUMMARY

Interrelations between three types of criteria of leanness-fatness (skinfold thickness, width of subcutaneous adipose tissue measured on roentgenograms of the limbs, body density) were examined in 52 men, averaging 57 years in age.

The coefficient of correlation between skinfold measurements at the dorsum of the upper arm and the corresponding roentgenogrammetric values was 0.82.

The average skinfold value, obtained with the pressure of 10 gm/mm^2 of the contact surface of the caliper, corresponded to 82% of the doubled width measured on the roentgenograms.

Equations for predicting body density, used as an indicator of total body fat, were calculated for single sites and for combined lateral-plus-medial or ventral-plus-dorsal roentgenographic measurements.

Relating the width of the layer of subcutaneous fat to stature, bony

width of the extremity, or to the width of bone-plus-muscle has not improved importantly the correlation with body density.

According to the available evidence, the validity of which is limited by the relatively small size of the present sample, measurements made on roentgenograms of the extremities do not appear to be more effective indicators of leanness-fatness than direct (skinfold) measurements. However, a systematic appraisal in terms of multiple regression analysis remains to be carried out.

A comprehensive analysis of the value of measurements made on soft-tissue roentgenograms should include sites on the trunk not accessible to the skinfold-caliper technique. Proper attention should be given to factors of age and sex.

ADDENDUM

When this paper was completed, in the course of a discussion, Dr. E. E. Hunt, Jr. pointed out the potential advantages of using the calculated (approximate) crosssectional areas of the adipose tissue, related to the non-adipose ("lean") tissues of the limbs, as a roentgenographic criterion of fatness. This can be done in the present study for 4 locations in which the skin-plus-fat thicknesses were measured on both sides of the limb (upper arm, half-way up from the olecranon, in mediolateral projection; upper arm, one-third up, antero-posterior projection; thigh, one-third up from the patella, A-P projection; calf, A-P projection).

TABLE 8

Adipose areas, expressed as percentages of the lean areas in ½ limb cross sections, and the coefficients of correlation of these percentages with body density (r)

LOCATION	MEDIAN	MEAN	S. D.	*N*	*r*
Upper Arm, midway	32.6	34.5	11.5	52	—.72
Upper Arm, lower ⅓	49.6	53.4	14.5	41	—.68
Forearm	24.1	24.3	7.3	51	—.79
Calf	20.2	21.9	7.1	47	—.56

Assuming that the limbs are circular (which, strictly speaking, they are not), the areas of the total crossection and of the "lean" cross-section were calculated from the total and the muscle-plus-bone diameters, respectively. The "adipose" area was obtained by subtraction and expressed as a percentage of the lean area. The descriptive data and coefficient of correlation with density are given in table 8.

The *r*'s are essentially identical with the values obtained by relating the linear measurements of skin-plus-subcutaneous tissue to the "lean" limb width (bone + muscle, see Table 7, column $X/(B+M)$). Only for the Forearm is the *r* higher than when the absolute value of skin-plus-subcutaneous fat is used, disregarding body size, and even here the difference is trifling (—.76 vs. —.79).

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A COMMENT ON WILBER'S "ORIGIN OF HUMAN TYPES"

BY STANLEY M. GARN

Fels Research Institute, Yellow Springs, Ohio

DR. C. G. Wilber has taken the trouble, in the December 1957 issue of *Human Biology,* to refute the notion that simple climatic determinism explains the geographical and local races of man. While rendering a service to the reader who has not followed the periodical *Evolution,* he has, in his article, contributed several errors that bear mention here.

In particular, Wilber is concerned with the inadequacy of Allen's and Bergmann's "rules," as they pertain to homeotherms in general, and especially to *Homo.* As examples of exceptions he says that "the hippopotamus, rhinoceros and elephant are built on the roly-poly, globular principle, but are well entrenched in their tropical environments" (Wilber, '57, p. 332). At least two of these three examples possess unique adaptations, one of them (the elephant's ears) definitely increasing the body surface to an important degree, and the second (the hippopotamus' aquatic habits) serving to immerse the animal in coolant, thus extending the surface area indefinitely.

However, it is in regard to the Eskimo, a group with which Wilber has personal experience, that serious errors are made. Quoting Jenness, he writes that "with respect to *all* Eskimos" (italics are mine) "they incline toward slenderness, the body tapering a little below the broad shoulders" (p. 333).[1] And, as evidence of this generalization, he cites Ray's 1885 height-weight data on Point Barrow males and females. These data, however, yield little proof of slenderness. In both sexes the Point Barrow weight-height ratio is high. Ray's Point Barrow

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females, though five inches *shorter* than Ohio white females (Garn, '57a), still averaged two pounds *heavier*. If these figures bear quoting, they strongly support the assumption of a high mass/volume ratio for Eskimos!

Similarly, among Aleut children, the weight-to-height ratio is distinctly high, as Wilde ('50) has shown for the St. Paul Aleut, and C. F. A. Moorrees and I have demonstrated for the Attu-Atka-Umnak Aleut (Garn and Moorrees, '51). Hrdlička's data on Kuskokwin Eskimo children may also be cited (Hrdlička, '41). As data both on Aleut children and on adult Aleut show (Laughlin, '49), there is a pronounced reduction in the long bones and peripheries, a trend in the expected direction, if it is assumed that reduction of the peripheries may be a genetic adaptation to a cold climate.

Wilber also makes much of the facts that many Arctic-dwelling people keep their homes at an elevated temperature, quite uncomfortable for us, and possess the best-engineered clothing that existed prior to the development of the deep-sea diver's dress. The latter, at least, is obvious. One must be equipped for the cold to exist in it (*cf.* Coon, Garn and Birdsell, '50, pp. 66-67). The former becomes irrelevant, as soon as we remember that cold-selection operates out-of-doors, on the hunt, driving sledges, when feeding reindeer, or even at quite moderate temperatures, paddling a thin-bottomed kiyak from Atka to Attu. It is out-of-doors rather than snug at home that differential survival of the shorter-limbed, better-padded Eskimo may have contributed to the high weight-height ratios and shorter limbs that persist today.

It is not to be expected, however, that generalizations are any more than generalizations, and when we encounter a human population repeatedly exposed to some potentially selective factor, it becomes imperative to look for multiple adaptations, using experimental techniques as Wilber suggests.[2] At least two differences, probably indicative of genetic and not physiologic adaptations are known for Southampton Eskimos. One is the maintenance of higher peripheral skin temperatures, under conditions of cold-water immersion (Brown and Page, '52); the second, and more puzzling, is the maintenance of lower intramuscular temperatures under the same conditions (Brown, Hatcher and Page,

[2] Here a quotation from Volpe is pertinent. "In many studies on evolution, there is a tendency for investigators, of which the writer claims to be no exception, to interpret, or rather 'fit,' their data to prevailing evolutionary theories, rather than to design experiments to test critically the validity of the current postulates or to exploit new possibilities." (Volpe, '58, p. 367).

'53). These are not quite "typical" tropical adaptations but suggest the possibility of a complex of adaptations to cold.

However, as I have pointed out before, the critical test is not the simple possession of possibly-useful adaptations, but rather differential survival (Garn, '57b, p. 220).

I thoroughly agree with Dr. Wilber that man is primarily a heat-adapted animal, as performance experiments and man's unique sweat-gland system both attest. He is, moreover, a speed animal, a rather lightly-muscled collection of folding bones, to paraphrase Christopher Fry. Nevertheless there are indications in the way body size and body proportions are distributed about the world, that some generalizations pertinent to other homeotherms do apply to man (*cf.* Roberts, '53). Despite air-conditioning and central heating, the majority of men still venture out-of-doors, and thus subject themselves to temperature selection.

I know of no anthropologist so rash as to claim that temperature and the radiant heat load are exclusive or even major causes of the differences between geographical races, or that the past-century formulations of Bergmann and Allen completely solve the problems of race formation in man. I know of none who adopt the Lamarkian approach that Dr. Wilber so gleefully demolishes. But, when Wilber asserts that "the rules of Bergmann and Allen have *no* causal role in the formation of racial differences in man" (p. 335), I doubt very much that he intended such a sweeping and untestable counter-generalization.

NOTE

In regard to climatic adaptations, there are several recent articles. It is not entirely clear, however, whether they all score a point for Wilber, or for the present author.

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BOOK REVIEWS

Principles of Research in Biology and Medicine. By DWIGHT J. INGLE. xv + 123 pp. Lippincott, Philadelphia, 1958. $4.75.

Professor Ingle, well-known physiologist associated at present with the Ben May Laboratory for Cancer Research, University of Chicago, has been one of the moving forces behind the establishment of the new journal *Perspectives in Biology and Medicine*, designed to facilitate communication of ideas among scientists. He has been disturbed, as were others, by the danger growing from the steadily rising pressure for space in scientific journals, resulting in editorial policies that emphasize the most concise presentation of data and limit severely historical considerations of the problem and the discussion of the results.

While to Ingle the history of biological science is essentially the history of great hypotheses and their protagonists, he is no advocate of uncritical thinking or armchair speculation. As an experimentalist, Ingle is well aware of the restrictions that must be placed on ideas. Experimental evidence, and this includes a proper statistical analysis of the data, is the unquestioned court of appeal, the experimental scientist's only genuine criterion for the discrimination between fact and fancy. Yet, experiment *and* theory are inseparable parts of scientific inquiry. Answers do depend, in part, on questions we ask and the synthesis of data (as differentiated from a mere summation of isolated facts) requires perspective, i.e. theory. The choice of worthy goals is the most difficult problem facing the scientist, once the technical tricks of the trade had been mastered and material opportunities for investigative work had been secured.

The *Principles* are an expression of Professor Ingle's concern about the more general (philosophical) aspects of research, aspects he finds entertaining personally and considers, with justification, as being commonly neglected in scientific education. The creative scientist differs in important ways from the skilled but unimaginative technician, even though the essential differences are subtle, hard to analyze adequately and, consequently, at the present time, beyond control and transmission by educational methods. "It is no more possible," says the author, "to teach a scientist how to make a great discovery than it is possible

to teach a poet how to write a great poem, an artist to paint a great picture, or a composer to write a great symphony" (p. viii).

Yet, in addition to factual information and manipulative skill that must be acquired by the student of a particular biological discipline or medical specialty, there are general principles concerning the gathering of data ("experimental design") and their interpretation that *can* be taught. The present book is the fruit of the conviction that these principles *should* be taught.

A large part of the volume is devoted to spelling out the difficulties inherent in establishing a fact. The unaided perceptual organs of man are sensitive only to a small proportion of energy manifestations, and they are incapable of precise quantitative appraisal even when the stimuli fall within the sensory range. Consequently, much of the scientist's effort goes into development of physical aids for the detection and measurement of natural phenomena. The scientist should be aware of the seductive effects of suggestion, frequently subtle, upon his perception and thought processes. Bias must be avoided in the sampling of populations under study and in the execution of experiments.

Defining a cause of any specific event as "any necessary antecedent or concomitant event or condition" focuses attention upon the complexity of "causes" and the importance of concomitant conditions. In addition to the relatively stable framework of "necessary conditions," the author lists several categories of "permissive" (supporting, secondary) causes and analyzes the "active" causes as variables that a) trigger the response of a system already organized for response, b) facilitate a reaction as catalysts, or c) induce response by transmitting energy directly to the system.

There is an interesting discussion of "heteropoietic" (difference producing) factors, the naturally occuring extrinsic and intrinsic variables (such as species differences and genetically determined biochemical individuality, sex, age, activity, emotionality, characteristics of the physical environment, food intake, physiological rhythms, and adaptation) which may affect responses to a given experimental regimen. The last chapter deals with "Relationships among Scientists," both at the educational level and in reference to various forms of organized research.

Throughout it is stressed, for the benefit of the experimenter and the clinical investigator, that statistical methods are of increasing importance in the design of experiments as well as in the interpretation of the data. The two aspects, design and analysis, are intimately connected. No claim is made that formal statistical analysis is an

infallible guide to decision or that it replaces common sense. Neither the earth-bound training in specific research techniques nor an exposure to the more rarified atmosphere of philosophy of science can provide a sure guide for dealing successfully with the unknown—the goal of all "fundamental" research. But awareness of the general principles of research should usefully widen the student's perspective and sharpen his criteria of scientific proof.

The present volume is the handiwork of a thoughtful scientist, not of a professional philosopher of science. On the whole, this is all to the good. It is reflected in the effective use of references to problems encountered in actual investigative work, and in the addition of a welcome and healthy psychological element to the purely logical considerations of "truth and consequences." Thus enjoyment of inquiry is regarded as such an important ingredient of scientific investigation that it is listed, together with understanding of natural phenomena and their prediction and control, among the general aims of science: "Research should be fun. It should be possible for the scientist to find enjoyment in the laboratory and in the fellowship of scholars throughout his life." And again: at the introductory level, "science should be presented in all its color, beauty and drama, indeed, the exciting qualities of science should not be lost from graduate education or from life in the laboratory, although discipline and attention to detail is also required."

This is not a systematic *Handbuch* and was never intended to serve as such. Readers will vary in regard to the items they should like to see treated in greater detail. Here are some topics that might be considered in the next edition: Financial aspects of research, including the benefits and limitations of contract research. Problems resulting from increasing cost and complexity of instrumentation. Effects of the steadily rising flood of publications and the new developments in the "retrieval" of scientific information. The growing disproportionality between periods of "inspiration" and "perspiration" in scientific research. The potential conflict, in individual scientists, between the devotion to science—the all-demanding mistress—and personal responsibilities to one's family and the community.

There are points that could be criticized, such as topical sequence or the unevenness of style. Some parts read like well written essays. Others resemble lecture outlines, and some ("Basic assumptions of science," p. 4; "Fallacies," p. 60) are little more than inventories of titles.

However, the reviewer's criticisms concern only the periphery. The core is solid, stimulating and worthwhile—not only for the intended audience of research workers in their fetal or neonatal state but also for the seasoned veteran. While Ingle wrote for students, he expressed a conviction that the mature investigator may profit at times from looking at his own handiwork from a greater distance. In fact, he should be a student of the philosophy of research throughout his life.

The reviewer is convinced that more than one reader—at some point or another in the perusal of the slim volume—will respond like one of Ingle's favorite heroes of detective fiction: "It makes one furiously to think." Can there be a greater compliment?

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Changes in Body Water Compartments During Growth. By BENT FRIIS-HANSEN. ii + 68 pp. Ejnar Munksgaard, Copenhagen, 1955. (Acta Paediatrica Supplement 113).

Here is an important description of the relative loss of body water in children during growth. It was written by one of the most active investigators of the subject, and stems from years of collaborative work carried out both in Boston and in Copenhagen. This and other recent studies have provided considerable data on the growth of body fluid compartments in infants and children, but published information on adolescents is still scarce. Furthermore, the physiological mechanisms which regulate these changes are still very poorly known.

Friis-Hansen begins his monograph by describing the observations of ancient Greek and Roman writers on the relatively high moisture content of human infants. He then reviews the methods and hypotheses underlying the measurement of body water in the living, and defends his procedures as among the more practicable for work on the young. The dilution of deuterium oxide in the blood after injection is his estimate of "total" body water: while the comparable dilution of thiocyanate approximates the "extracellular" fraction of body fluids. The difference between these two "spaces" is taken as the "intracellular" water.

This review is adequate except for a curious lack of references to

recent work on the density and hydration of the "fat-free" body—particularly the research at Minnesota summarized most fully by Keys and Brožek in 1953 (Physiological Reviews *33*:245-325).

Friis-Hansen's data pertain to 62 boys and 31 girls, ranging from neonates to a few teen-agers. For some of these children, both deuterium oxide and thiocynate determinations were completed, but for most, only one of the two measurements was carried out. The sample came from hospitals, but was evenly distributed above and below recent norms of stature and weight as related to age. The norms used were the closely similar ones for Denmark and Boston.

Friis-Hansen's statistical treatment consists of regressions of the logs of weight, stature, and body fluid compartments on the log of age from birth. He also makes use of surface area calculated from stature and weight. For each constituent, he separates his combined sample of both sexes into 5 age-groups, and has computed 5 linear regressions.

The logarithmic scale of age from birth is awkward in that it is so greatly stretched in the first few postnatal days. This difficulty is avoided by adding an interval equivalent to the average human gestation period, so that the scale approximates the log of conceptional age (*cf.* Hunt *et al.*, 1958, Human Biology *30*:73-91). Even this device, however, only slightly reduces the number of regressions of log measurements on log conceptional age which seem to be indicated by the data. The allometric relationships between the constituents, however, are far more regular and simple, as Friis-Hansen and others have shown.

On the basis of his regressions on small age-samples, Friis-Hansen assumes that no sex difference exists in the growth trends of his measurements. Most large-scale growth studies in the literature, however, indicate a true sex difference in weight—especially in pre-school and adolescent samples. It would appear from the evidence, however, that the true sex difference in body *composition*, as opposed to weight alone, is inconsequential before pubescence.

Friis-Hansen's most important findings are that in the first postnatal year, the percentage of extracellular fluid in the body decreases while the intracellular fraction stays fairly constant. In the second year, both fractions increase—very likely along with a decrease in total body fat. Later on, the extracellular compartment continues its decrease: while the intracellular fraction show only minor changes. These trends seem to reflect the increasing cellularity of the growing body, with a concomitant relative decrease of extracellular fluid.

To sum up: the weaknesses of this monograph are minor, and it is a most satisfying example of Scandinavian workmanship in human biology.

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EDITOR'S NOTE: Two other important monographs, neither of which was available to Friis-Hansen, were later published on the subject of body composition: 1) Human Standard and Maximal Metabolic Rate in Relation to Fatfree Man. By Wilhelm von Döbeln. 79 pp. Stockholm, 1956. Acta Physiol. Scand. *37*, Suppl. 126, 2) The Gross Composition of the Body. By William E. Siri. Adv. Biol. Med. Physics, *4*:239-280. 1956. Cf. also Evaluating Body Composition. By George R. Cowgill. Borden's Rev. Nutritional Res. *19* (No. 1):1-17, 1958.

Heights and Weights of Children and Youth in the United States. By MILICENT HATHAWAY. 131 pp. Home Economics Research Report No. 2. U. S. Department of Agriculture. U. S. Government Printing Office. 1957. $0.65.

Standard of heights and weights are useful to many disciplines concerned with child health. But where to find suitable standards has been a constant worry. Doctor Hathaway has done a great service by collecting the best available in the United States. Most importantly, she has emphasized the source of the data, with particular reference to date of collection and the geographical location of the children concerned. How often are we guilty of comparing to-day's child born and bred in X state with standards compiled in 1920 in Y state? The compilation is limited to height and weight data on white boys and girls from 2 to 18 years. How lamentable it is that well collected data on the Negro child are precious and rare; he provides a large measure of child health problems in this country.

The first part consists of general tables from studies in 34 states and the District of Columbia. Classification is by region, State and date of study, and at the end of each table of a certain age there are admirable and purely arbitrary standards for that age. These are considered the best available data. To give an idea of the comprehensive nature and labor of Doctor Hathaway's work, there are, for example, 68 sets of data listed under 9 year old boys.

The second section presents selected height-weight standards from different sources and examples of forms and graphs in use. It was good to see, for comparative and historical interest, that Hastings' much neglected and admirably collected data of 1889 were given. This section is valuable because it deals with the distribution of the measurements in the samples and affords some idea, usually by percentiles or standard deviation, of the range of "normality." A most curious fact can be seen on studying the Jackson-Kelly growth charts where, very properly, percentiles are used for 'channels' of growth in weight, and standard deviations for height: in several places the curves of plus or minus 1 standard deviation from the mean are clearly not equidistant from the mean curve. This discrepancy has found its way into some of the corresponding table and there are therefore some plus 1 standard deviations which are different to the corresponding minus quantities—clearly an impossibility.[1] Perhaps the original calculations of the deviations were not traditional. This most interesting section is enhanced by the author's descriptive notes heading each set of data.

The third section deals with some factors affecting growth patterns and here such variables as nationality, socio-economic status, decade of measurement, and rate of maturity are plotted to show their effects. This last factor—rate of maturity—affords the necessity to write a note of sadness: the presentation of Doctor Nancy Bayley's most important curves of the growth of children maturing at different rates are the only ones giving incremental or velocity data in the entire vast collection. Sad because many of us need velocity standards so badly, and because the presentation of longitudinally collected data cross-sectionally is hardly getting the most out of hard invested work. It need hardly be said that not one tittle of criticism is directed here at Doctor Hathaway —the published data were not there for her to seek and find.

Finally, the last part consists of an annotated list of literature references. It is comprehensive and is made doubly useful by the excellent annotations.

This paper-backed report should certainly be in the hands of all students of growth and development.

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[1] Doctor Hathway is now aware of these discrepancies and corrections are available.

The Numbers of Man and Animals. Edited by J. B. Cragg and N. W. Pirie. 152 pp. Macmillan, New York, 1957. $2.75. (Originally published by Oliver and Boyd, London, 1955).)

This small volume contains the very stimulating record of a symposium held in England in 1954 by the Institute of Biology. The objective of the conference was to assemble specialists from the wide variety of sciences which in some way are concerned with the growth of animal and human populations, in order to discover how much common ground existed and to highlight gaps in our knowledge. The orientation of the volume is well expressed by the editors: "The growth of human populations is strongly influenced by social and cultural factors which are much less important in other species. For all that, *Homo sapiens* is an animal and many aspects of his relationship with his environment, with other species, and with other members of his own species, should be open to biological analysis."

The book contains 13 all too brief contributions by illustrious specialists in economics, demography, cultural anthropology, mathematics, biology, human ecology and other disciplines, most of which are followed with only occasionally provocative discussions. The papers range over such topics as an economic theory of optimum population, the effects of nutrition on fertility, illustrative mathematical models of population dynamics, research in the biology of conception and the future possibilities of telegenesis, experimental competition in beetles, and glimpses of the future population and natural resources of the world.

To any reader who is a specialist in any area covered, the contributions from that area, with few exceptions, will probably seem quite familiar. But for most members of the natural and social science fraternities, at least a third and probably more of the selections will provide both new information and fresh points of view. One cannot help but be profoundly impressed with the number and diversity of important perspectives brought to bear on the subject of population growth. For anyone interested in this subject, this little book is a genuinely educational experience. The only negative reaction stems from having one's appetite whetted and so quickly frustrated by the brevity of the offerings.

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Mastery of Stress. By D. H. FUNKENSTEIN, S. H. KING and MARGARET E. DROLETTE, Harvard University Press, Cambridge, Mass., 1957.

The book reports the results of a two-year investigation carried out with men attending Harvard College. The title is rather misleading, in that mastery and stress are dealt with only within the narrow confines of distinctly limited experimental conditions: performing arithmetical problems (with some "heckling") and reading a story under conditions of "sonic confusion" in which the subject heard, by means of earphones, his own voice with a slight delay. The main variables were as follows: characteristics of sequential reaction to repeated presentation of the "stress" situations (i. e. in the authors' words, whether "stress was mastered"), physiological reactions and patterns, direction of "emotional" reaction (e. g. "anger-in," "anger-out," "anxiety"), and perception of parental roles. With reference to the last item, the investigation represents a most commendable pioneering effort relating perception of parental roles to physiological reactions and performance.

The main purpose of the physiological measurements was to test the hypothesis that—contrary to Cannon's thesis—physiological reactions do actually differentiate between different emotional states, that—for example—anger-out is a nor-epinephrine reaction and that anxiety is an epinephrine reaction. It is a very questionable point in this reviewer's mind whether the amount of emphasis given to this dichotomy between epinephrine and nor-epinephrine is justified by the data or by the heuristic value of such a distinction. In any event, considerably more physiological data are required before concluding that physiological reactions furnish generally reliable means of differentiating anger and fear.

Wholly apart from the matter of the reason for including physiological measures in the present study, the physiological part of the investigation may be criticized for omitting some key physiological indicators (such as palmar conductance and respiration) that may well have produced results leading to different conclusions. The actual choice of indicators appears arbitrary. The authors admit that their interpretation of the exact physiological mechanisms lying behind the ballistocardiographic tracings is highly conjectural, and they mention the difficulty that clinicians have "in getting the same tracings on the same patients on repetition," suggesting that the inconsistencies may be due to "shifts in the patients' emotional reaction to the testing situations at different times." However, such inconsistencies could very possibly

be due to inherent unreliabilities in the measurement process itself. Actually, estimations of reliability are not given for methods employed in the present study.

In my judgment, one of the most serious weaknesses of the book is that although it is amply discursive, the authors do not appear to seek any manner of satisfactory nexus with current psychological theories. References to such theories are limited to writings of nearly two decades ago. The term "emotion" is used repeatedly without any reference to recent psychological papers dealing with this topic, and to closely related topics such as that of motivation. Indeed, it is surprising that the term "motivation" does not even appear in the index. Crucial terms ("anxiety," "depression," "stress," "conflict," "frustration") are not defined with sufficient rigor, in my opinion. Moreover, in some instances, terms denoting particular emotions are used interchangeably with terms denoting diagnosis of complex psychopathological states.

Despite its defects and omissions, this study represents an important piece of investigative work. Its importance does not lie mainly in the conclusions permitted by the findings, although there are a considerable number of suggestive findings. Rather, this work—as I see it—is important for its originality, as a long step forward into a new research area. It is to be hoped that the authors will continue along these fruitful lines.

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Verbal Behavior. By B. F. SKINNER. x + 478 pp. Appleton-Century-Crofts, New York, 1957. $5.50.

Man's ability to verbalize is his most advanced and unique form of behavior. The outstanding contribution of Skinner's book is to offer a framework in which man's verbalizations can be examined with the same objectivity and scientific rigor as other aspects of his behavior. Skinner views previous attempts to systematize the terminology describing verbal behavior as failing to provide the techniques necessary for a causal analysis of human speech. He believes that approaches such as semantics, logic, grammar, and rhetoric are essentially dualistic in their conceptualizations. Terminology such as "ideas," "images," and "meanings"

imply a "mentalistic" or inner component in man which is distinct from his overt and observable behavior. In contrast, Skinner postulates that the lawful relationships embodied in speech are the same as those governing all other human behavior. In his experimental work, Skinner has gone further than any other scientist in eliminating the "mind-body" dichotomy.

Skinner conceives of this book as being an exercise in "interpretation" rather than an extrapolation of previous experimental results. Thus he deliberately avoids citing the psychological literature in this area. From the viewpoint of the research specialist, it is unfortunate that Skinner limited himself to the briefest mention of an ever-increasing body of data which support his approach to verbal behavior. However, the general reader will find that his procedure of using literary and philosophical writings as his primary data greatly enhances the readability of the book.

For those readers who may be unacquainted with Skinner's views about man, science, and society, it is suggested that this book be read in conjunction with two of his previous works, "Science and Human Behavior" and "Walden Two." The latter is a science fiction version of the ideal society based on Skinnerian conditioning principles. As in these previous volumes, Skinner is saying that under the proper conditions all human behavior, including verbalization, is understandable, predictable, controllable, and manipulable. In this age of hidden persuaders," "subliminal perception," and "brainwashing," a book which deals with the lawful effects of one person's behavior upon that of another person must have important consequences.

It should be pointed out that this book has been long anticipated. Skinner has presented his basic views about verbal behavior in university courses at Minnesota, Harvard, Chicago, and Columbia, and mimeographed material from these courses has been circulating for the past ten years among interested researchers. Skinner's influence on American psychology is increasing at a rapid pace. If one can judge the importance of a book in a scientific field by the amount of research it generates, then it is highly probable that this book will be a scientific landmark.

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BOOK NOTICES

INTRODUCTION TO BIOSTATISTICS. By Huldah Bancroft. x + 210 pp. Paul B. Hoeber, New York, 1957. $5.75. Developed in the course of teaching biostatistics to sophomore medical students at Tulane University. In addition to the usual materials, short chapters on life tables and bioassay are included.

GENERAL SYSTEMS, Vol. II. Edited by Ludwig von Bertalanffy and Anatol Rapoport. xiii + 188 pp. Yearbook of the Society for General Systems Research (R. L. Meier, University of Michigan, Ann Arbor, Mich., Secretary), 1957. No price indicated. The second Yearbook continues to provide a forum for a variety of approaches, reflecting the fact the interests in the problem range from preoccupation with mathematical models to philosophical speculation, with emphasis on human behavior as subject matter.

ANATOMIST AT LARGE. By George W. Corner. v + 215 pp. Basic Books, New York, 1958. $4.00. An informal but informative autobiography (pp. 3-64), followed by essays ranging from technical topics (Physiology of the Corpus Luteum) to philosophy and history of medicine. Appropriately, the author upon retirement as Director of the Department of Embryology of the Carnegie Institution became the historian of the Rockefeller Institute for Medical Research.

EVOLUTION OF GENETIC SYSTEMS. By C. D. Darlington. x + 265 pp. Basic Books, New York, 1958. $5.50. While the title is the same as that of the 1939 edition, the present volume is essentially a new book, motivated by the purpose "to join together the relatively fixed world of physics and chemistry and the undoubtedly moving world of biology," "to see how the shape of our knowledge is being changed today just as it was changed in the past by the work of Mendel, Darwin and Pasteur."

SCIENCE AND THE CREATIVE SPIRIT. By Karl W. Deutsch, F. E. L. Priestley, Harcourt Brown and David Hawkins. xxvii + 165 pp. University of Toronto Press, Toronto, 1958. $4.50. Four essays on humanistic aspects of science. "While this book results from an effort to reduce the area of disagreement betwen humanist and scientist, it does not seek that end by denying that conflict exists."

AGED IN AMERICAN SOCIETY. By Joseph T. Drake. ix + 431 pp. Ronald Press, New York, 1958. $5.50. Presentation of gerontology in sociological framework. Part IV deals with physiosomatic and psychosocial characteristics of the aged.

DARWIN'S CENTURY. By Loren Eiseley. xvii + 378 pp. Doubleday, New York, 1958. $5.00. A vivid portrait of "evolution and the men who discovered it."

CHEMICAL ANATOMY, PHYSIOLOGY AND PATHOLOGY OF EXTRACELLULAR FLUID. By James L. Gamble. 164 pp. Harvard University Press, Cambridge, Mass., 1958. $2.25. Sixth edition, attesting the continued usefulness of this lecture syllabus.

FUNDAMENTALS OF NEUROLOGY. By Ernest Gardner. xi + 388 pp. W. B. Saunders, Philadelphia, 1958. No price indicated. Third edition, revised with special attention to sensory endings in muscle, to vision, and to basal ganglia.

FADS AND FALLACIES IN THE NAME OF SCIENCE. By Martin Gardner. x + 363 pp. Dover Publications, New York, 1957. $1.50. A revised and expanded edition of this study in human gullibility, reviewing "the curious theories of modern pseudoscientists and the strange, amusing and alarming cults that surround them."

CURRENT TRENDS IN THE DESCRIPTION AND ANALYSIS OF BEHAVIOR. Edited by Robert A. Patton. 242 pp. University of Pittsburgh Press, Pittsburgh, 1958. $4.00. A series of 9 papers on topics ranging from psychophysiology to psychoanalysis, focussed on the problem of description—preferably quantitative—of behavioral phenomena.

INDUSTRIAL PSYCHOLOGY. By Thomas Willard Harrell. xiv + 398 pp. Rinehart & Company, New York, 1958. $6.00. Revised edition of a college textbook, first published in 1949, emphasizing the concept of motivation.

JOB ATTITUDES: REVIEW OF RESEARCH AND OPINION. By Frederick Herzberg, Bernard Mausner, Richard O. Peterson and Dora F. Capwell. xii + 279 pp. Psychological Service of Pittsburgh, Pittsburgh, 1957. No price indicated. Beginning with the problems of the prevalence of job dissatisfaction and the characteristics of dissatisfied workers, the authors critically review the voluminous literature on different aspects of job attitudes, ending appropriately with the considerations of mental health in industry.

GROWTH OF LOGICAL THINKING FROM CHILDHOOD TO ADOLESCENCE. By Bärbel Inhelder and Jean Piaget. xxvi + 356 pp. Basic Books, New York, 1958. $6.75. Monograph on the development of problem solving behavior, with emphasis on the period from 11 to 15 years, crucial for the study of the transition from the concrete thought of the child to the formal thought of the adolescent.

MANUAL FOR NUTRITION SURVEYS. Interdepartmental Committee on Nutrition for National Defense. viii + 160 pp. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 1957. $1.50. Designed "to serve as a guide for survey teams in collecting data for an assessment of the nutritional status of a population." Includes measurement of skinfold thickness (p. 29).

PHYSIOLOGY OF MAN. By L. L. Langley and E. Cheraskin. x + 674 pp. McGraw-Hill, New York, 1958. $6.95. Second edition of an introductory text, "dedicated to the proposition that learning can be fun."

PRESERVATION OF YOUTH. By Moses Ben Maimon. Transl. by Hirsch L. Gordon. 92 pp. Philosophical Library, New York, 1958. $2.75. Written in 1198 for the Sultan of Egypt and now translated from the Arabic original, the essays provide an interesting picture of the medieval views on various aspects of the medieval curative and, in particular, preventive medicine.

HUMAN ENGINEERING. By Ernest J. McCormick. xi + 467 pp. McGraw-Hill, New York, 1957. $8.00. "Human engineering," concerned with the principles underlying the rational adaptation of equipment, work space, and work environment for human use, is essentially an interdisciplinary enterprise, with contributions from engineering, physical anthropology, medicine, physiology, and psychology. The book covers the field with emphasis on the contributions of psychology.

CURRENT STUDIES IN PSYCHOLOGY. By F. J. McGuigan and Allen D. Calvin. xiii + 226 pp. Appleton-Century-Crofts, New York, 1958. $2.65. A useful presentation of selected recent (since 1950) papers in several fields of psychology (learning, motivation, growth and development, personality, perception, social factors), made accessible to beginning undergraduate students.

BIOGRAPHICAL MEMOIRS, Vol. XXXI. National Academy of Sciences. vi + 396 pp. Columbia University Press, New York, 1958. $5.00. Includes, among others, biographies of E. G. Conklin (biologist), W. S. Hunter (psychologist), R. Linton (anthropologist) and J. P. Peters (biochemist).

DECENNIAL SUPPLEMENT (ENGLAND & WALES, 1951)—AREA MORTALITY. By the General Register Office. xxviii + 82 pp. British Information Services, New York, 1958. $12.50. Mortality statistics contribute to biochemical knowledge in terms of changes over time, differences between social and occupational groups, and differences between regions. The present volume presents death rates for geographical subdivisions of England and Wales during the period 1950-1953.

TISSUE ELASTICITY. Edited by John W. Remington. vii + 203 pp. American Physiological Society, Washington, D. C., 1957. $4.50. The visco-elastic properties of living tissues are of interest to physicists and chemists (protein structure and elasticity) as well as to biological scientists studying elastic properties of muscles, blood vessels and lungs. W. O. Fenn considered elasticity in the human body (p. 98). A useful glossary of terms (p. 191) is appended.

METABOLISM OF THE NERVOUS SYSTEM. Edited by Derek Richter. xiv + 599 pp. Pergamon Press, New York, 1957. $16.00. Proceedings of the Second international Neurochemical Symposium, held in Denmark in 1956. The topics range from electronmicroscopy of nervous tissues to transmission in the central nervous system and drug action.

THE CHILD: A BOOK OF READINGS. Edited by Jerome M. Seidman. xiv + 674 pp. Rinehart & Company, New York, 1958. $6.75. Collection of writings,

presented in the original form, on various facets of child development, from infancy to adolescence. Three (out of 65) papers deal with neuromuscular growth.

MEASUREMENT AND STATISTICS. By Virginia L. Senders. xvi + 594 pp. Oxford University Press, New York, 1958. $6.00. "A basic text emphasizing behavioral science applications."

COMBINATION OF OBSERVATIONS. By W. M. Smart. xiv + 253 pp. Cambridge University Press, New York, 1958. $6.50. The treatment of observations and measures subject to errors constitutes the core of this volume. Of special interest are chapters 2 (Errors of observation), 5 (Measures of precision for weighted observations), and 8 (Correction of statistics).

HANDBOOK OF BIOLOGICAL DATA. Edited by William S. Spector. xxxvi + 584 pp. W. B. Saunders, Philadelphia, 1956. $7.50. This is the third publication resulting from an ambitious project to gather and compile, in handbook form, basic established data in the biological and medical sciences (Standard Values of Blood, 1952; Standard Values in Nutrition and Metabolism, 1954). A large number of the tables refer to man's biochemical characteristics, genetics and reproduction, development and morphology, nutrition, respiration and other physiological functions, environment and survival, and vital statistics.

UNDERSTANDING HUMAN MOTIVATION. Compiled and edited by Chalmers L. Stacey and Manfred F. DeMartino. xv + 507 pp. Howard Allen, Inc., Cleveland, 1958. No price indicated. The authors brought together 42, well selected, slightly abridged articles by authors of varied theoretical orientation, to provide a readable introductory text on the dynamics of human behavior.

PERSON PERCEPTION AND INTERPERSONAL BEHAVIOR. Edited by Renato Tagiuri and Luigi Petrullo. xx + 390 pp. Stanford University Press, Stanford, Calif., 1958. $7.50. Outcome of a symposium, held at Harvard University with the support of the Office of Naval Research, concerned with the ubiquitous problem of how we know and what we know about others.

NONPARAMETRIC AND SHORTCUT STATISTICS. By Merle W. Tate and Richard C. Clelland. ix + 171 pp. Interstate Printers and Publishers, Inc., Danville, Ill., 1957. No price indicated. Intended as a manual for graduate students and research workers in social, biological and medical sciences.

PERSONALITY: AN INTERDISCIPLINARY APPROACH. By Louis P. Thorpe and Allen M. Schmuller. v + 368 pp. Van Nostrand, Princeton, N. J., 1958. $5.50. Attempt at an introductory synthesis based upon the conviction that the study of personality must cut across many disciplines and draw upon psychology, psychoanalysis, sociology, education, social psychology and cultural anthropology.

ÜBER DIE ERBLICHKEIT DES NORMALEN ELEKTROENZEPHALOGRAMMS (On the inheritance of normal electroencephalograms). By F. Vogel. 92 pp. Georg

Thieme Verlag, Stuttgart, 1958. $2.30. The monograph is based on 208 pairs of twins, 6 to 30 years of age. The e. e. g. was taken during sleep, at rest and under the stress of hyperventilation and oxygen deficit.

BIOCHEMISTRY AND HUMAN METABOLISM. By Burnham S. Walker, William C. Boyd and Isaac Asimov. vii + 937 pp. Williams & Wilkins, Baltimore, 1957. $12.00. Third edition, keeping up with the advancements in a rapidly expanding field (including complete chemical analysis of a fresh adult human cadaver, in section on Tissue Chemistry). A large section (pp. 404-444) is devoted to the biochemistry of reproduction and heredity.

PERCEPTUAL DEVELOPMENT. By Seymour Wapner and Heinz Werner. 95 pp. Clark University Press, Worcester, Mass., 1957. No price indicated. The monograph deals with changes in spatial organization that takes place in the course of human growth, considered within the framework of a theory of perception which takes into account both the object-stumuli (psychophysical aspects) and the state of the organism (psychophysiological aspects).

PSYCHOTHERAPY BY RECIPROCAL INHIBITION. By Joseph Wolpe. xiv + 239 pp. Stanford University Press, Stanford, Calif., 1958. $5.00. The proposed theory of neurosis and the method of therapy stem directly from modern learning theory. It is offered as a serious alternative to the repression theory and the therapeutic practices of psychoanalysis which stresses the uncovering and expressing of "the repressed."

MEASUREMENT OF COLOUR. By W. D. Wright. ix + 263 pp. Macmillan, New York, 1958. $10.75. Up-to-date presentation of the principles, methods and applications of the trichromatic system of color measurement.

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INFORMATION FOR CONTRIBUTORS

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Where possible, illustrations should be made for reproduction as line engravings, hence drawn in India ink as boldly as possible. Lettering must remain legible after figures are reduced to fit on 4½ x 6½ inch pages (letters 1½ to 2 mm high after reduction are adequate). Figures should be numbered consecutively with Arabic numerals. Tables should be numbered independently from 1 up, and both figures and tables should have captions. When the amount of tabular and illustrative material is judged to be excessive or unusually expensive, authors may be requested to pay the excess cost. Galley proofs will be sent to the author and must be returned promptly; when the author makes substantial departures from copy, the cost will be charged to him. Three copies of an abstract (not to exceed 225 words) should be submitted when the proof is returned. One will be sent to the editor of *Biological Abstracts*.

References in the text to the literature should be made by using the author's name followed by the year of publication: "Studies of Garn and Saalberg ('53) . . ." At the end of the article, under the heading "LITERATURE CITED," full references with titles and inclusive page references should appear (double spaced) in alphabetical order of the authors' names: "GARN, S. M. AND J. H. SAALBERG 1953 Sex and age differences in the composition of the adult leg. Human Biol., 25: 144-153."

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Human Biology

a record of research

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